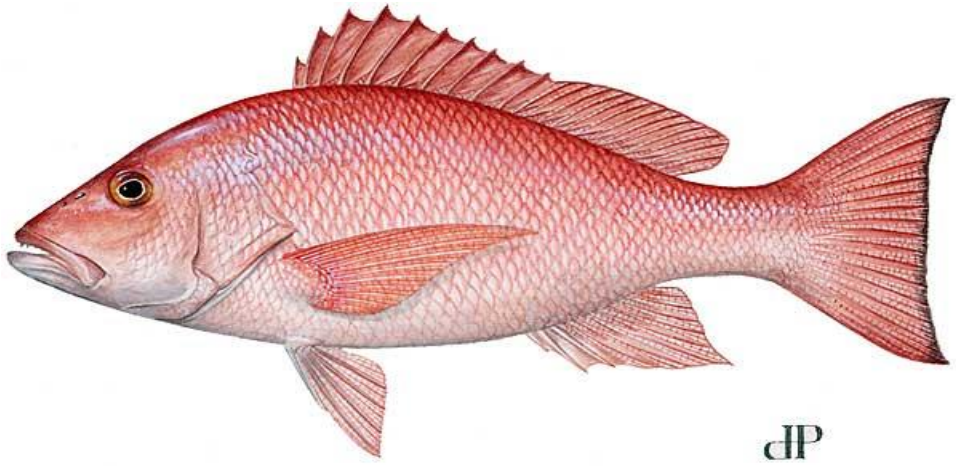
# Gulf of Mexico Red Snapper Stock Assessment

## A Data Rich Southeast Assessment

NOAA FISHERIES
Southeast Fisheries Science Center



SEFSC Staff
July 2014

# Outline

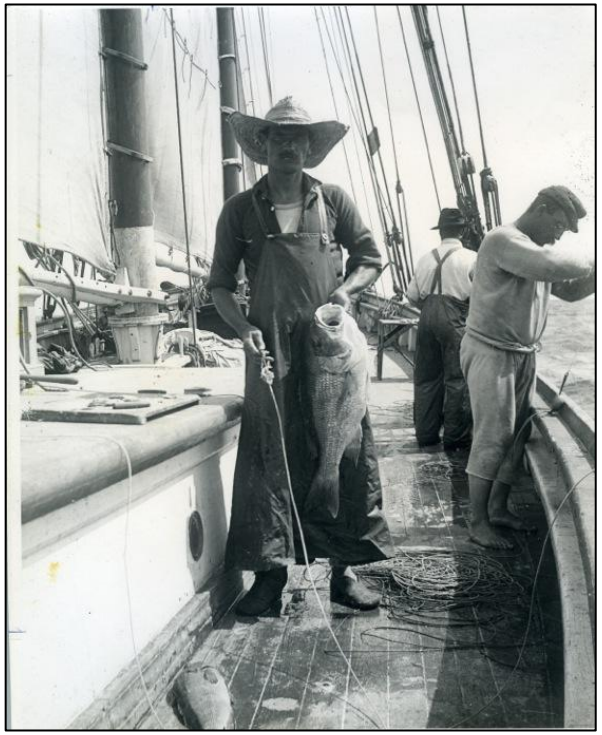
Description of latest Gulf red snapper assessment, focusing on:

- History of fishery
- Process, time and staff resources used
- Data preparation (amount, type, workload)
- Model description (input, code, uncertainty, projections)
- Reports and documentation
- Follow-up analyses and meeting presentations

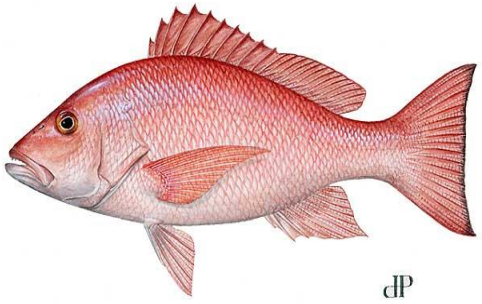
# History of Gulf Red Snapper

Long history of depletion:

- 1880s: “It is probable that this species is being more or less rapidly depleted” (Collins, 1885)
- 1950s: Most of the snapper banks off Florida considered impoverished (Camber, 1955).
- 1980s: 2 assessments indicate overfishing
- 1990s: 5 assessments indicate stock overfished and overfishing
- 2004, 2009 assessments: indicate stock overfished and overfishing occurring

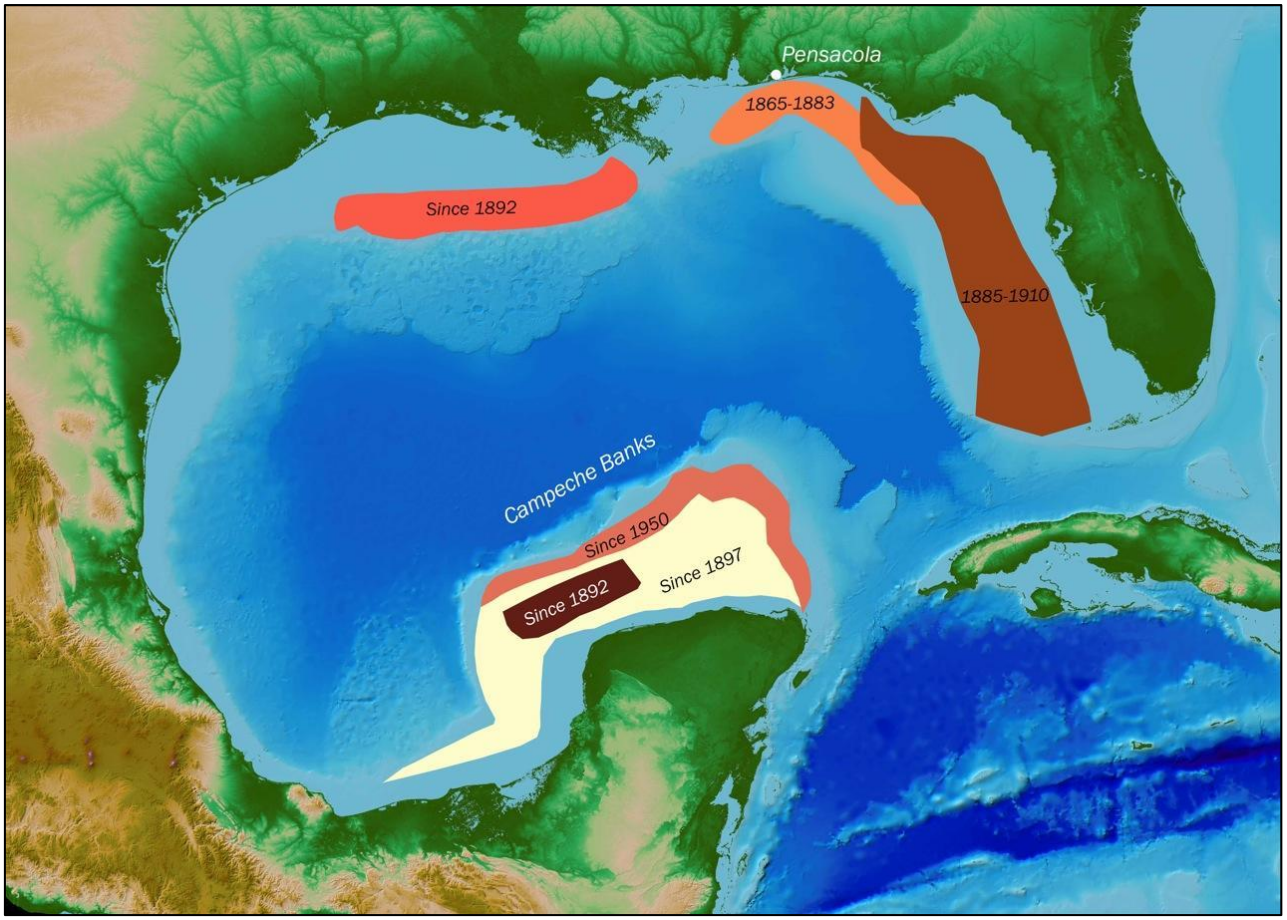


# Historical pattern of serial depletion



*Lutjanus campechanus*

historic fishing areas




Nicole Bacchino Florida Public Archaeology Network

# Time frame of an assessment

| Total staff | SEFSC staff | Event |
|---|---|---|
| ~30 | ~20 | June 2012 initial data call/prep |
| ~40 | ~20 | August 2012 DW |
| ~25 | ~10 | January 2013 AW |
| ~15 | ~5 | April 2013 RW |
| 2 | 1(+under study) | Summer/Fall 2013 Present to SSC |
| 1 | 1(+under study) | Fall 2013 Present to council |
| 1 | 1(+under study) | 2014 IPT, 2015 projection advice |

**SEDAR 31**
**Gulf of Mexico Red Snapper**
**Schedule of Events**

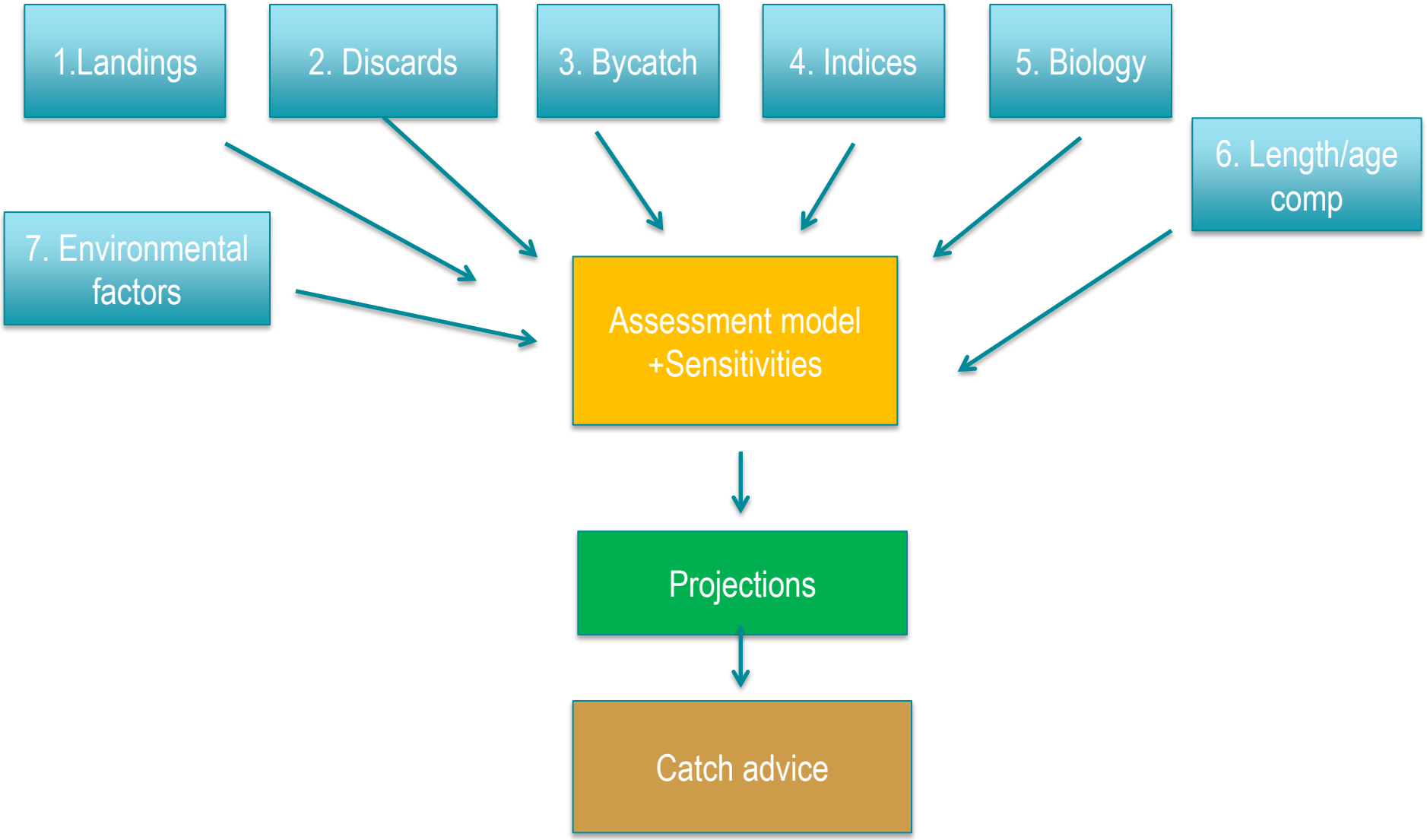
TORS and Schedule Approved ..... November 2011
Workshop Appointments Final ..... January 2012

Data Scoping Conference Call (DW Panel) ..... *week of May 28 or June 4, 2012*
Data Scoping Webinar (DW Panel) ..... *week of July 9, 2012*
*Review data series lengths, length frequencies, and summary statistics*
DW Working Paper/Data Submission to SEDAR Staff ..... August 3, 2012
Pre-DW Conference Call (DW Working Group Chairs) ..... *week of August 13, 2012*
**Data Evaluation Workshop (Pensacola, FL)** ..... **August 20-24, 2012**
1st Draft of Data Evaluation Workshop Report ..... August 24, 2012 (end of workshop)
Draft DW Reports to DW panel for review ..... September 7, 2012
Report Comments due to Editors ..... September 14, 2012
Final data workshop report sections due to SEDAR ..... September 28, 2012
Data workshop report distribution ..... October 5, 2012

Pre-Assessment webinar ..... *week of November 19, 2012*
*Discuss pre-base run model set up and questions, DW and AW participate*
AW working paper submission deadline ..... January 11, 2013
Distribution of functioning model and model documentation ..... January 18, 2013
**Assessment Workshop (Miami, FL)** ..... **January 28 - February 1, 2013**
Assessment webinar I ..... *week of February 11, 2013*
*Finalize base runs, finalize set of sensitivities, uncertainty methods, projection methods*
Assessment webinar II ..... *week of February 25, 2013*
*View sensitivities, uncertainty and projections*
Assessment webinar III ..... *week of March 11, 2013*
*View any final changes to model or report*
Assessment Report Draft to panel for review ..... March 29, 2013
AW report comments due to analysts ..... April 5, 2013
Final Assessment Report to SEDAR staff ..... April 12, 2013

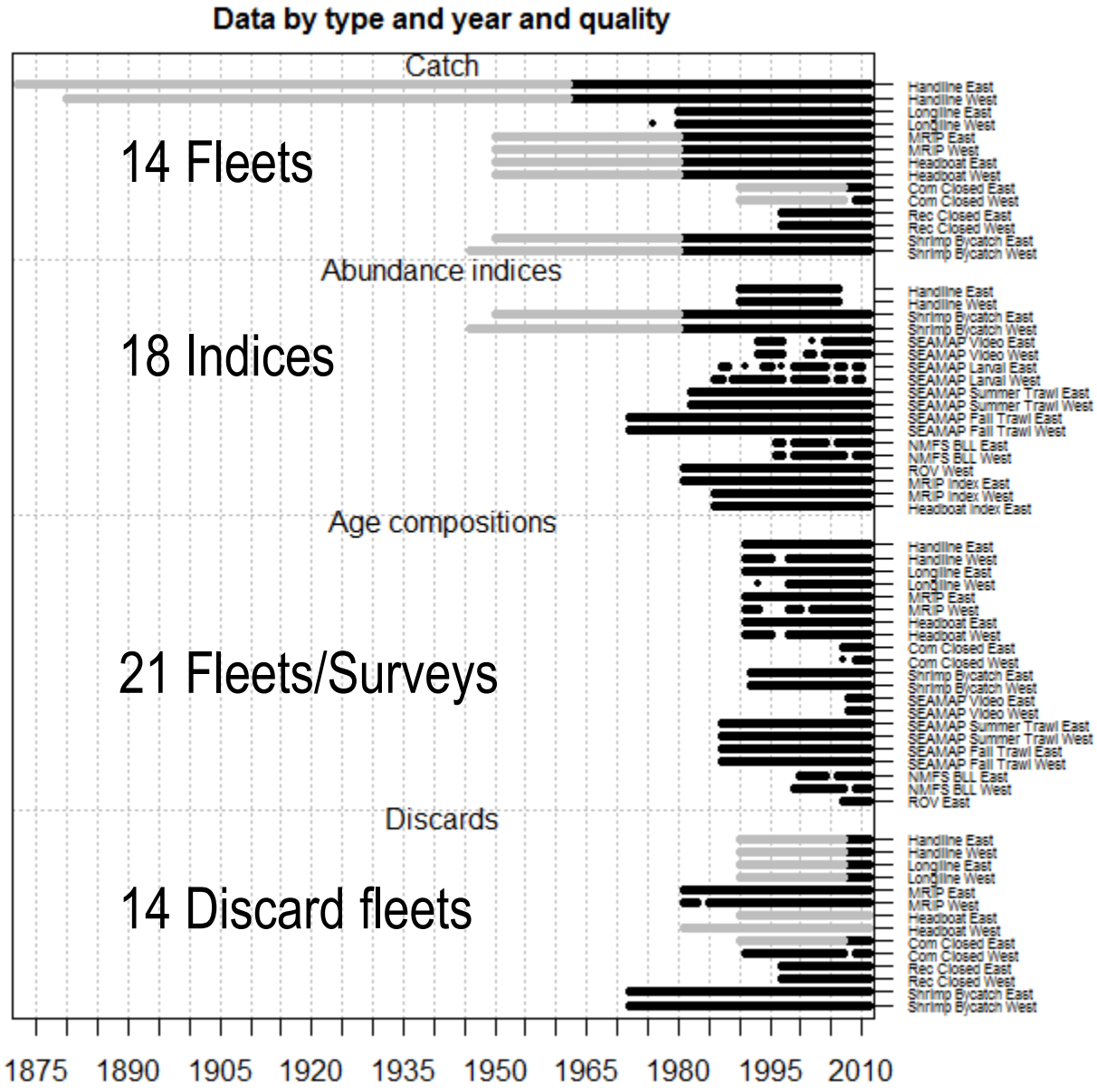
RW Working Paper Submission ..... April 15, 2013
Final AW Report distribution to review panel ..... April 15, 2013
*Pre-RW Conference Call (Analytical team, RW Chair)* ..... *week of April 22, 2013*
*RW Panel Introductory Conference Call (RW Panel, Chair)* ..... *week of April 22, 2013*
**Review Workshop: (Gulfport, MS)** ..... **April 29 - May 3, 2013**
Review Reports due to Chair ..... May 17, 2013
Review Workshop Addenda/Revision Reports due to Chair and SEDAR ..... May 24, 2013
Review Workshop Reports due to SEDAR Staff ..... May 31, 2013
Complete Assessment Report Submitted to Councils/SERO/SEFSC ..... June 7, 2013

# Data preparation→ model→ projections→ Catch advice

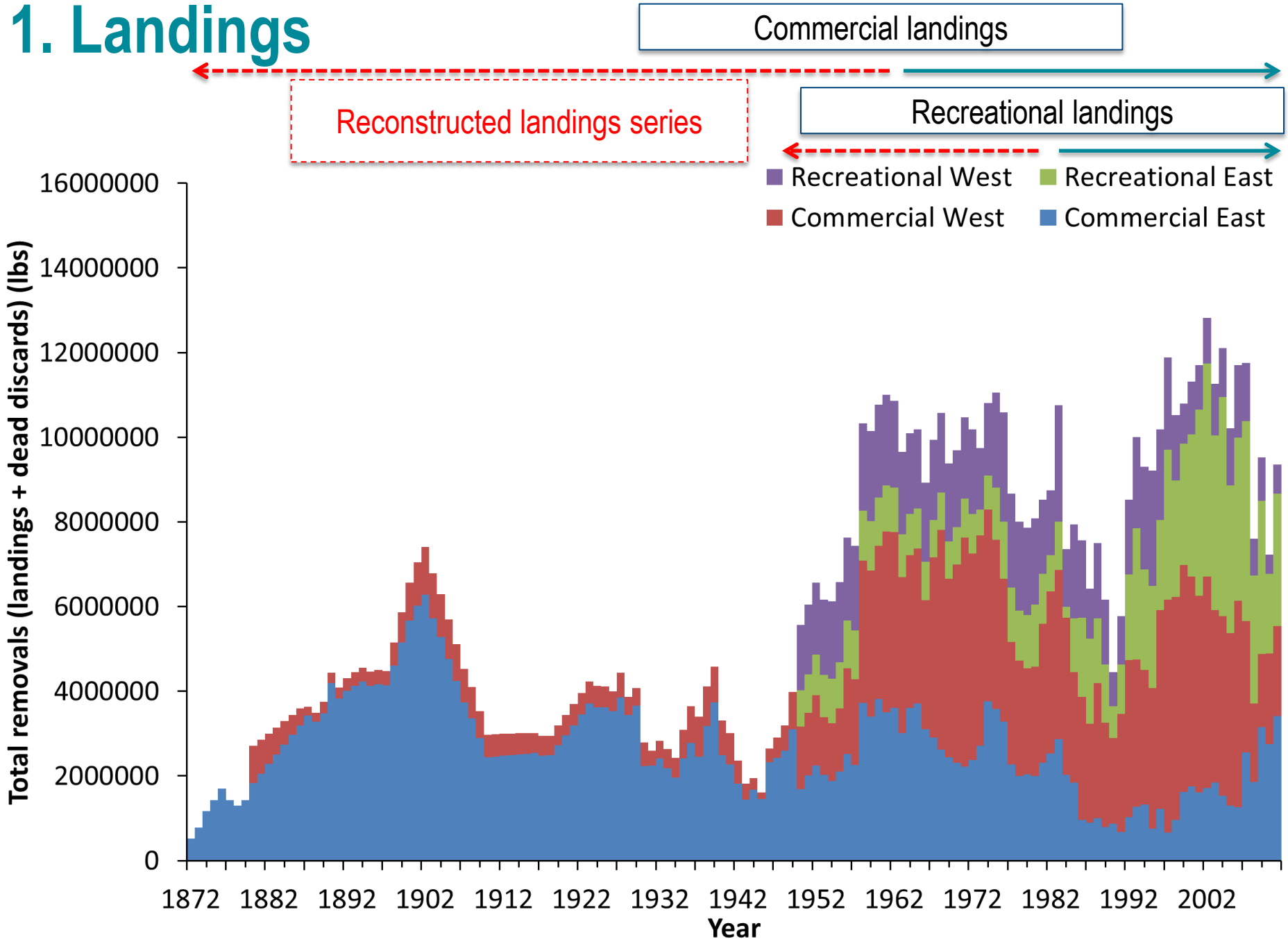


# Data by year

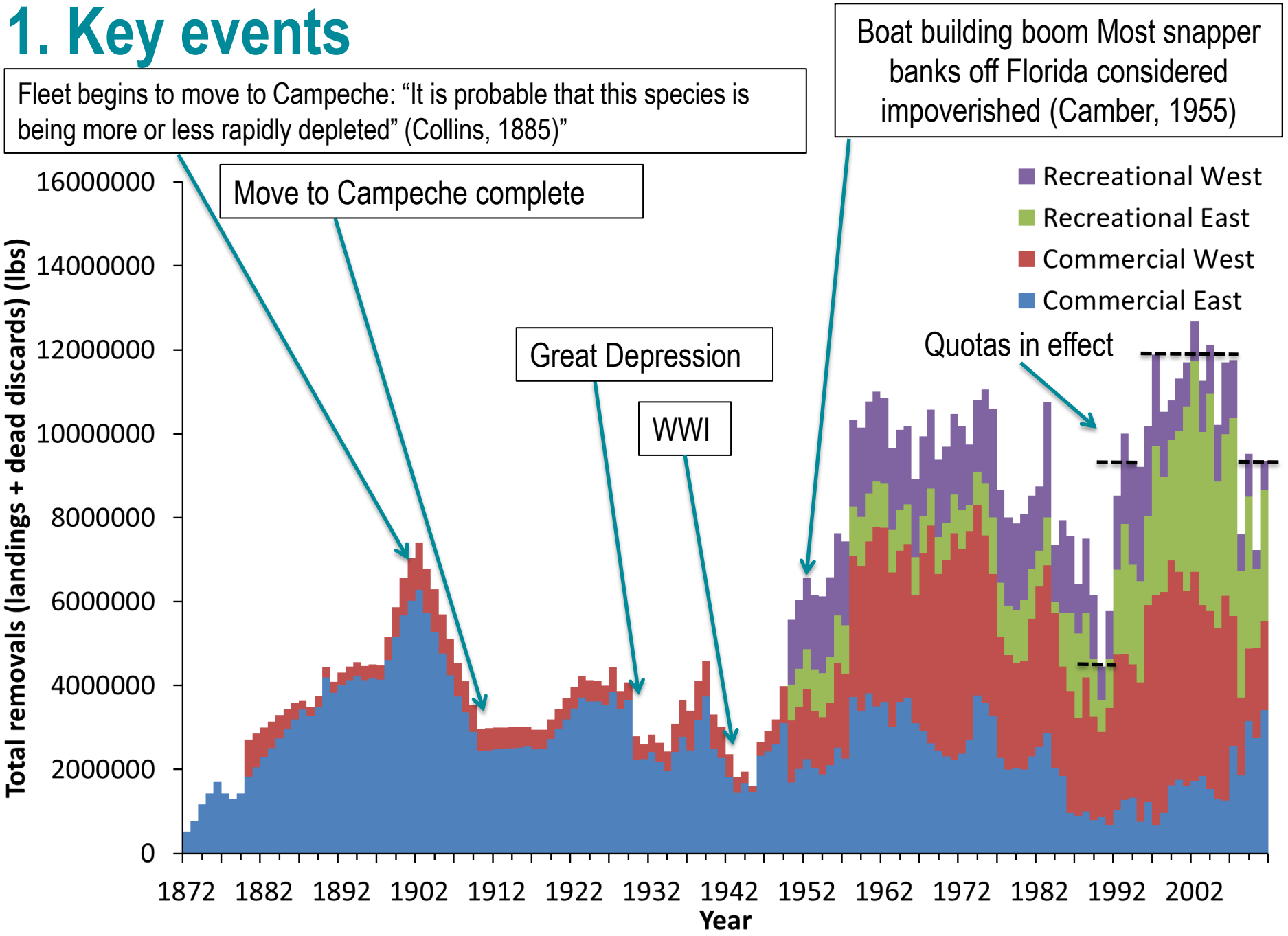
Estimated
Measured



# 1. Landings

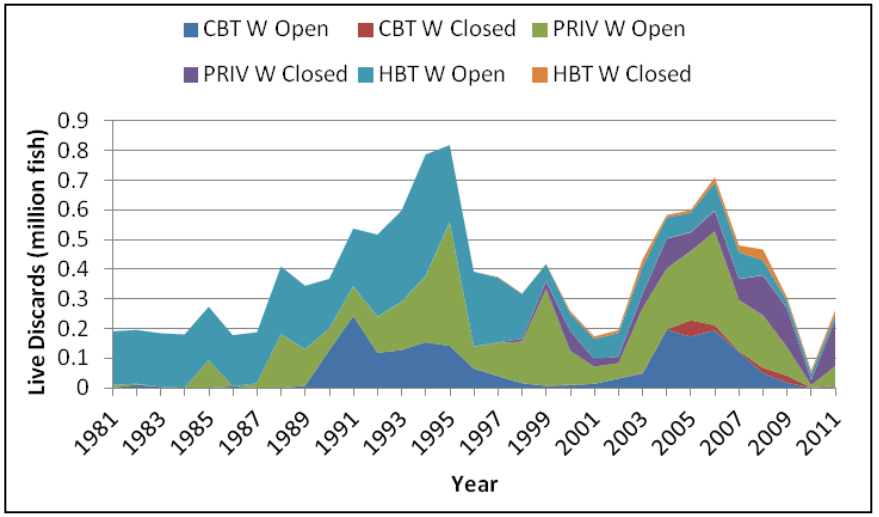

Commercial landings
Reconstructed landings series
Recreational landings
Recreational West
Recreational East
Commercial West
Commercial East
Total removals (landings + dead discards) (lbs)
16000000
14000000
12000000
10000000
8000000
6000000
4000000
2000000
0
1872
1882
1892
1902
1912
1922
1932
1942
1952
1962
1972
1982
1992
2002
Year

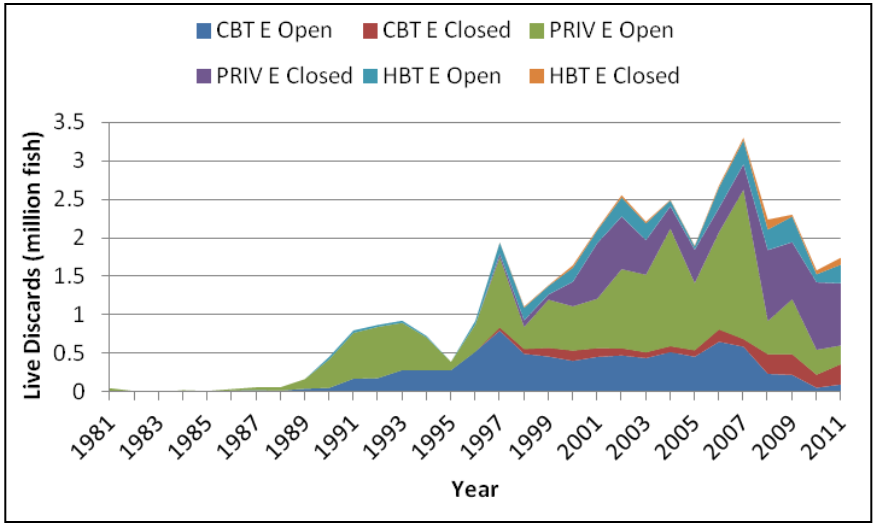
# 1. Key events


Fleet begins to move to Campeche: “It is probable that this species is being more or less rapidly depleted” (Collins, 1885)”
Move to Campeche complete
Great Depression
WWI
Boat building boom Most snapper banks off Florida considered impoverished (Camber, 1955)
Quotas in effect
Recreational West
Recreational East
Commercial West
Commercial East
Total removals (landings + dead discards) (lbs)
16000000
14000000
12000000
10000000
8000000
6000000
4000000
2000000
0
1872
1882
1892
1902
1912
1922
1932
1942
1952
1962
1972
1982
1992
2002
Year

# 2. Discards – high uncertainty / high impact

- Recreational/Headboat/Charter
  - High level of discards due to size and bag limits and closed seasons
  - Self-reported
  - Little information on size composition
- Commercial
  - Lower levels of discards
  - Low observer coverage for size and magnitude of discards
  - Closed seasons/size limits
  - Individual Transferable Quotas (ITQs) have created regulatory discarding when fishers have low or no shares



# Discard mortality

- High levels of discarding in many SE fisheries
- Many fisheries are in deeper waters, particularly snapper and grouper fisheries so barotrauma is a concern
- Regulations such as circle hooks and venting have attempted to reduce injury

Varies with:

- Depth
- Gear
- Season
- Temperature
- Hook type
- Fish size

# 3. Shrimp bycatch estimation

- Bayesian model predicts spatial/temporal bycatch rate
- Uses observer and research survey CPUE and shrimp fishery effort
- Shrimp fishery is major source mortality (> 30 million age 0 fish) but also most valuable fishery in Southeast
- Shrimp fishery bycatch influential in other fisheries
- Substantial research to reduce bycatch

# 4. Indices

## A. Fishery-dependent

- Longer time series than surveys
- Often predominant CPUE information for most stocks
- Regulatory measures (ITQs, size limits, etc) create constantly moving target
- Many steps taken to extract CPUE signal

## B. Fishery-independent surveys

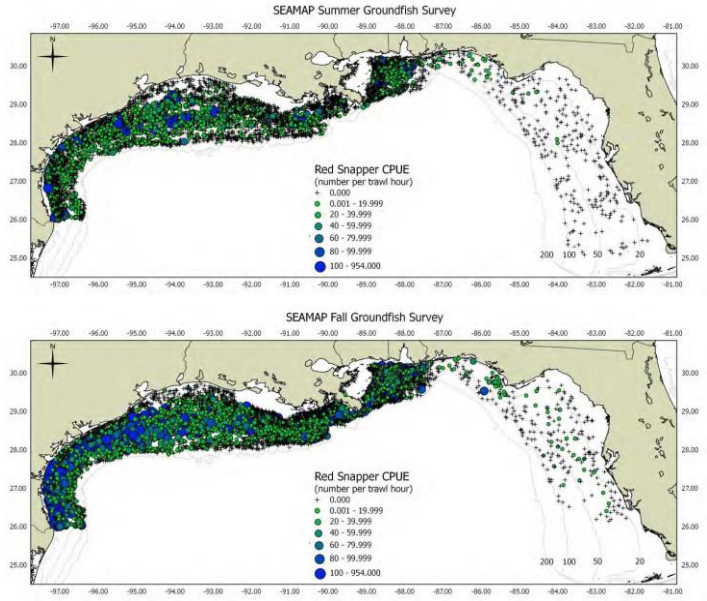
- Often short time series in localized areas or poor catch rates/high variability for key species
- Red snapper benefits from long-term surveys of both adults and juveniles
- Bottom longline survey- assumed logistic selectivity (flat-topped)
- Juvenile trawl (age-0)
- Often from multiple agencies/surveys

## C. Index evaluation report card

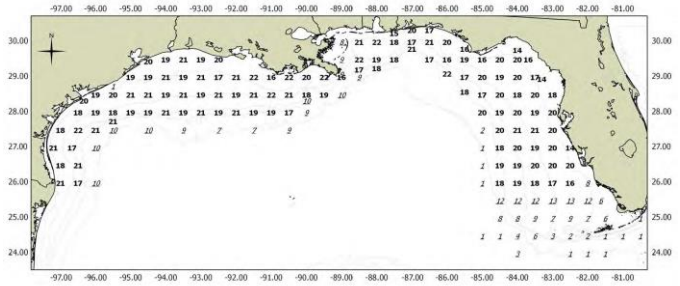
- Each index evaluated
- Factors: spatial and temporal coverage, index performance , data exclusion and treatment methods, appropriate handling of regulatory impacts, statistical modeling and diagnostics and overall applicability.

# Fishery Independent Data Sources

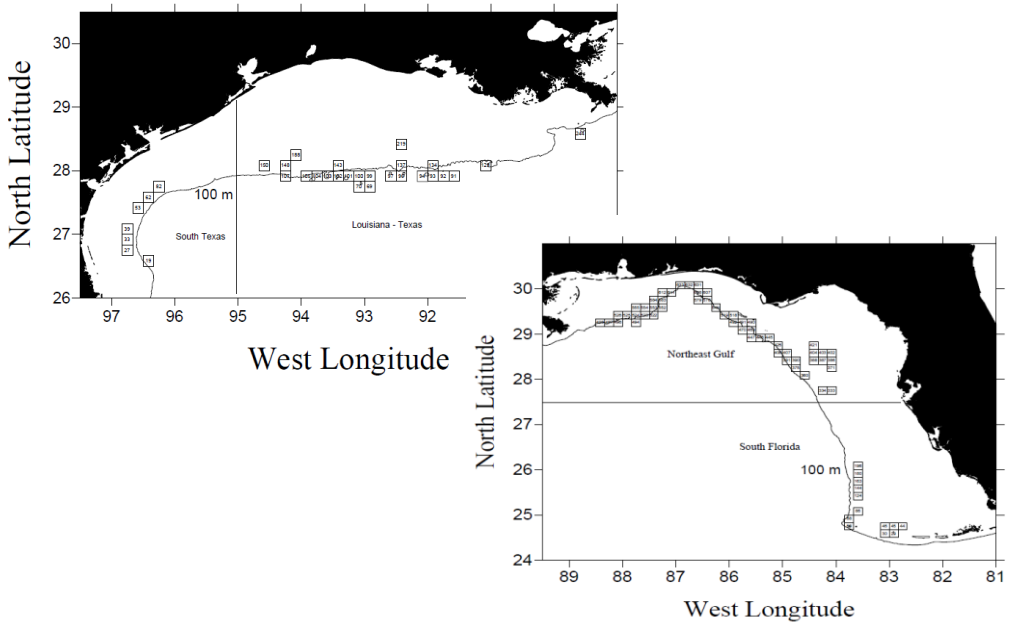
## SEAMAP Groundfish Survey



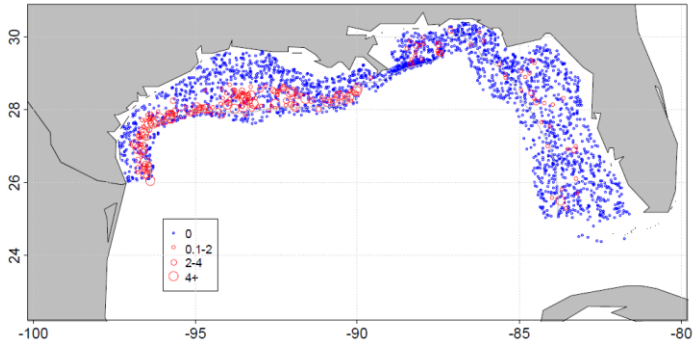

## SEAMAP Fall Plankton Survey



## SEAMAP Reef Fish Video Survey




## NMFS Bottom Longline Survey

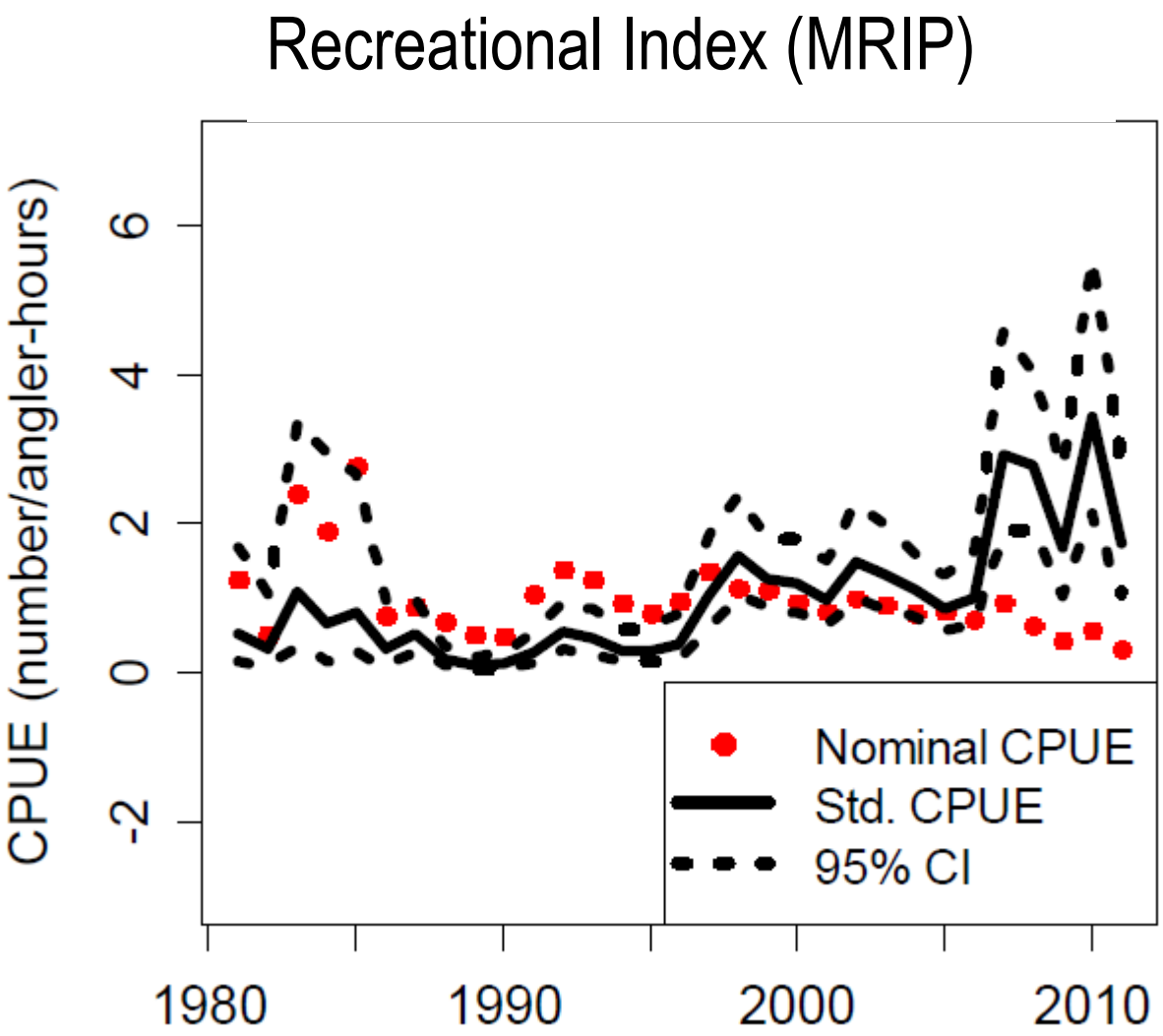


# Development of Fishery Dependent Indices

1. Data (MRIP/MRFSS, Vessel Logbook, Observer, Headboat survey)
2. Dependent variable: Catch per unit effort (CPUE) in landings or total catch
3. Subset data due to differential targeting
    - Define targeting due to presence of co-occurring species
4. Build statistical models with key factors
    - Generalized Linear / Mixed Models (GLM/GLMM)
    - Use key variables (year, area, season, gear, etc)
    - *year*area* interactions usually modeled with random effects
5. Predict year effect across balanced matrix  and obtain variances
6. Assess/Model Regulatory effects
    - Censored regression for bag limits
    - e.g. Switch to circle hooks (changed selectivity not CPUE)

# A Recreational Fishery Dependent Index



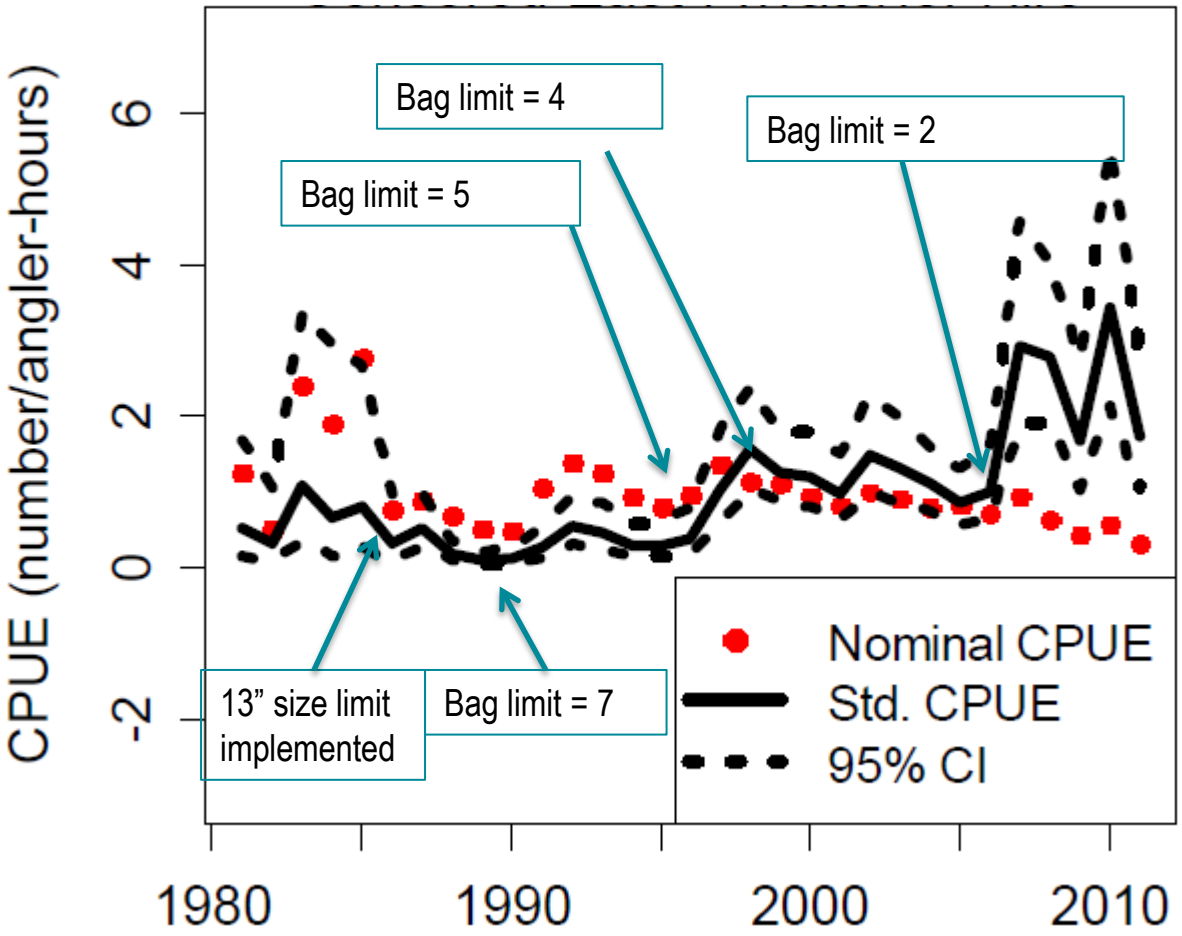



Nominal CPUE (red dots) appears at odds with fishers' experience of increasing abundance.

# Accounting for Regulatory Impacts



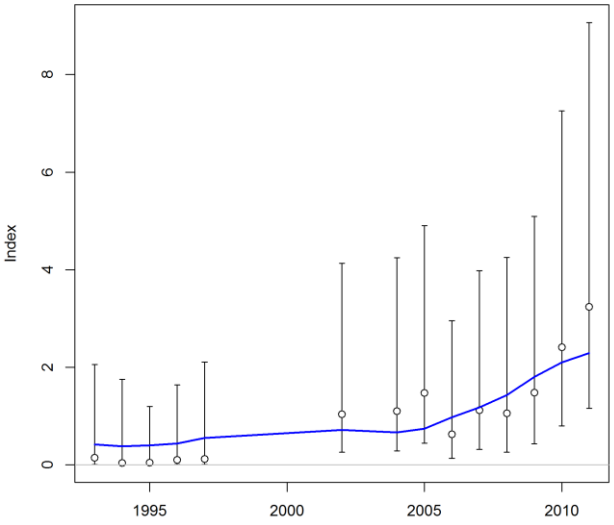
## Recreational Index (MRIP)



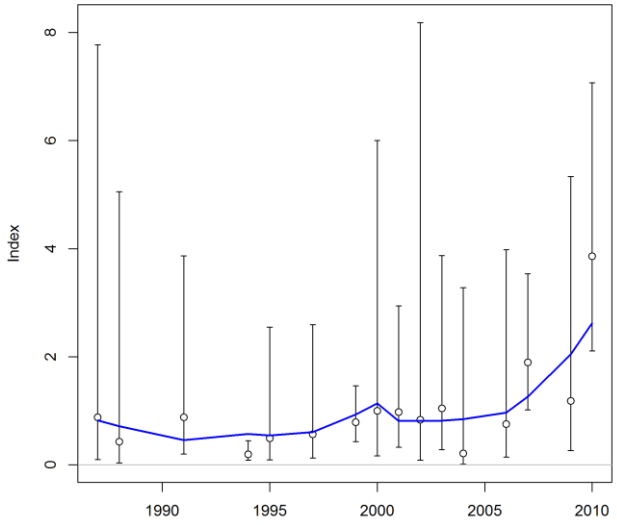

| Year | Size limit | bag limit | season length |
|---|---|---|---|
| 1986 | 13 | none | 365 |
| 1990 | 13 | 7 | 365 |
| 1995 | 15 | 5 | 365 |
| 1997 | 15 | 5 | 330 |
| 1998 | 15 | 4 | 272 |
| 1999 | 15 | 4 | 240 |
| 2000 | 16 | 4 | 194 |
| 2006 | 16 | 2 | 194 |
| 2008 | 16 | 2 | 65 |
| 2009 | 16 | 2 | 75 |
| 2011 | 16 | 2 | 48 |

# Fishery-Independent Indices of Adult Abundance

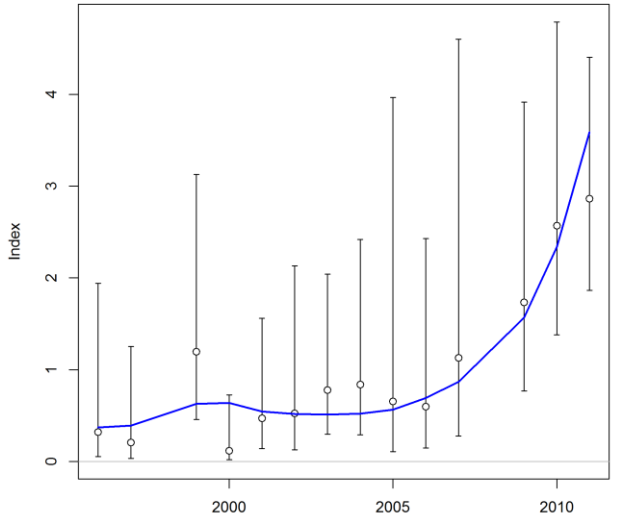
Video East



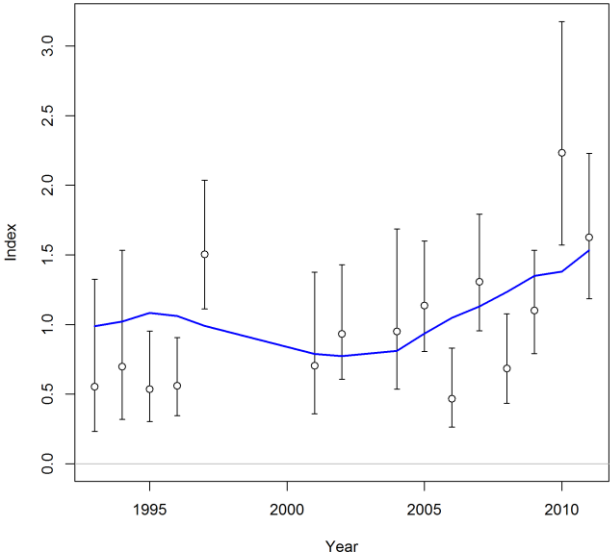

SEAMAP Plankton East



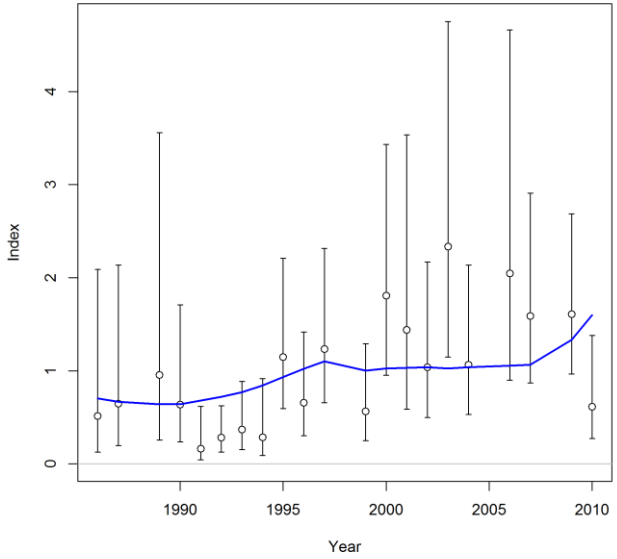

NMFS BLL East



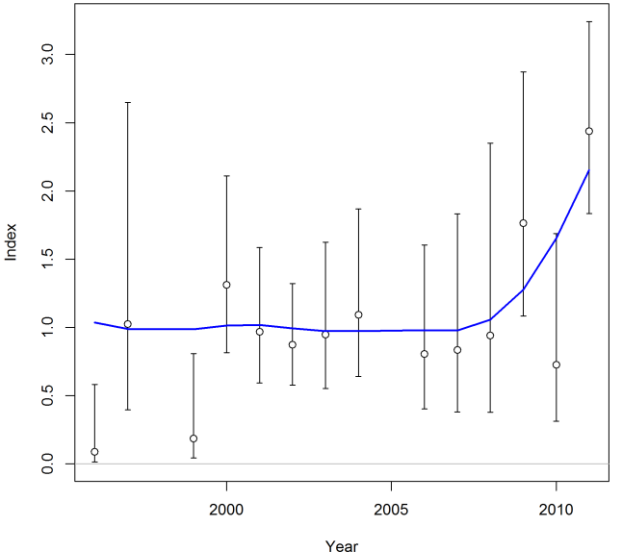

Video West




SEAMAP Plankton West

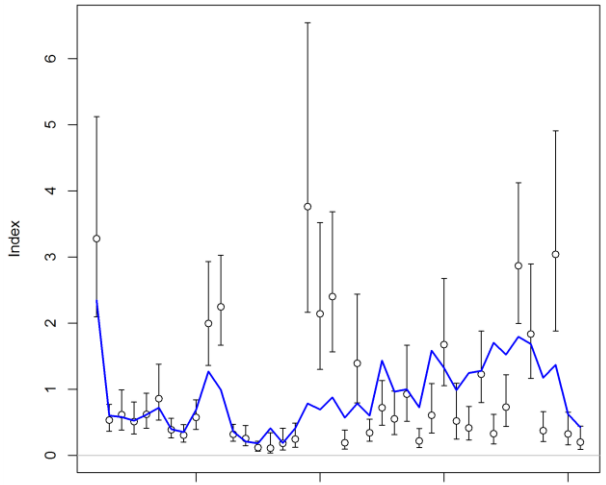



NMFS BLL West

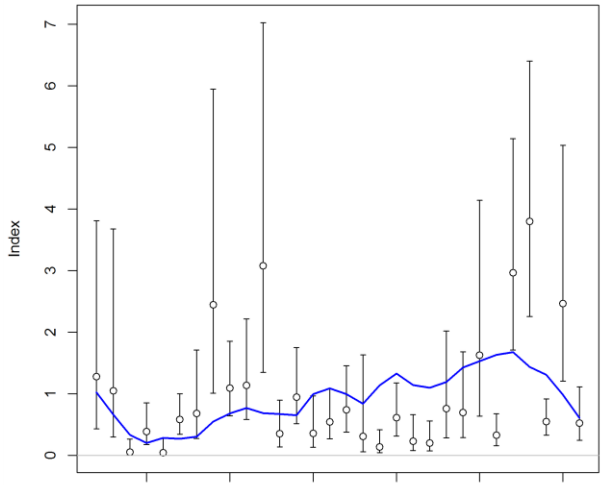


# Fishery-Independent Indices of Recruitment (ages 0 and 1)

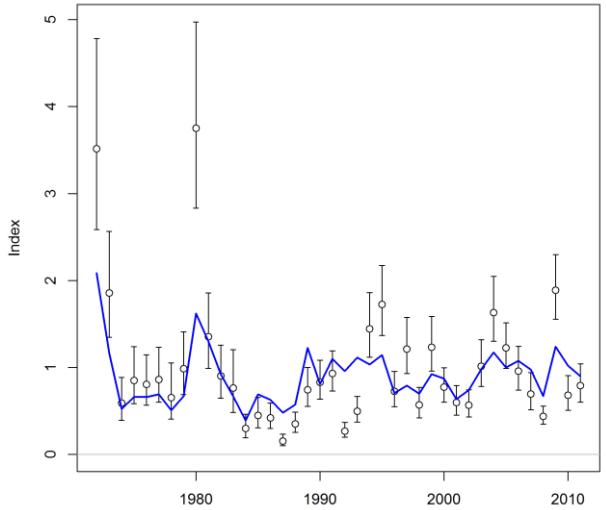
Fall Groundfish Trawl East



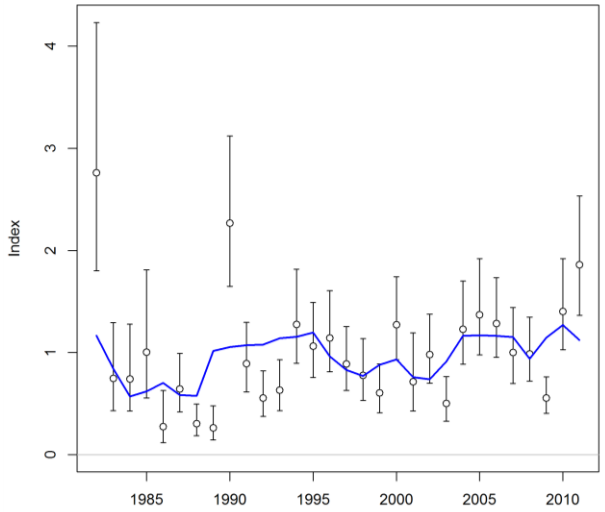

Summer Groundfish Trawl East




Fall Groundfish Trawl West

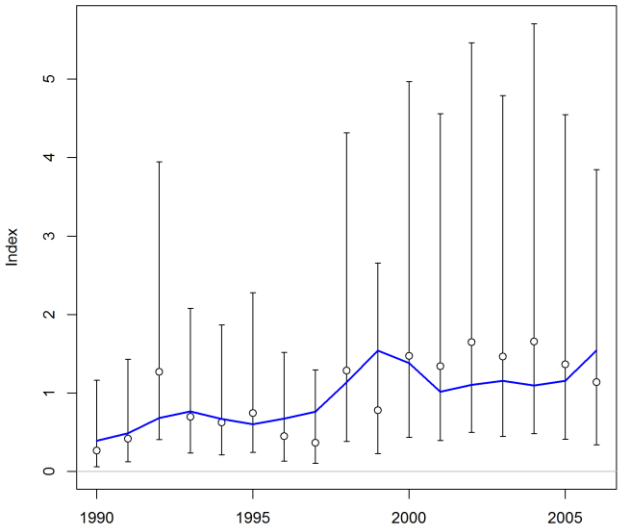



Summer Groundfish Trawl West

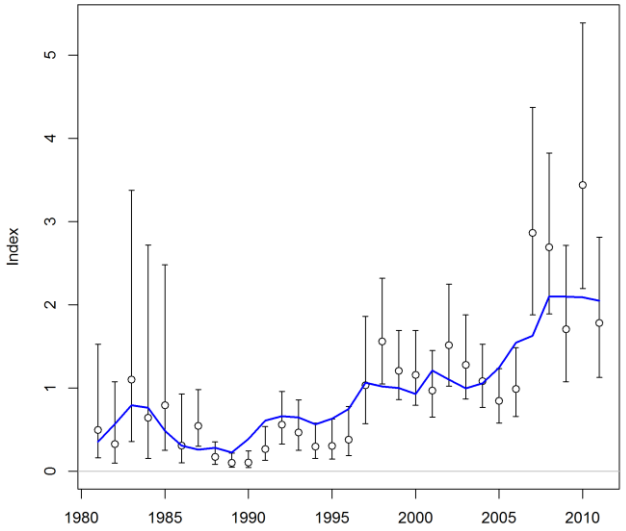


# Fishery-Dependent Indices of Abundance

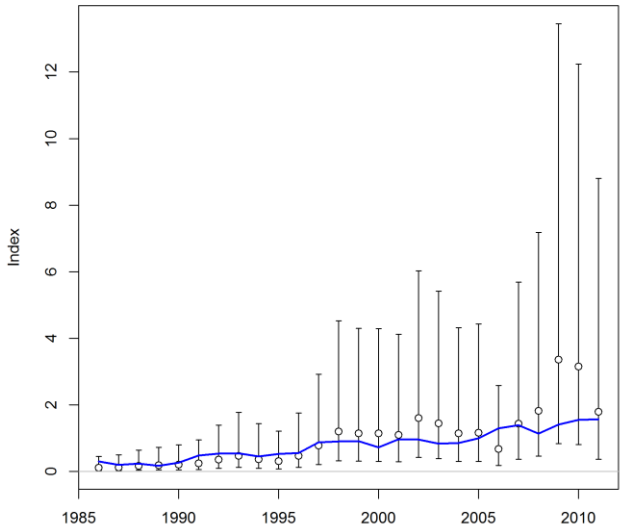
## Commercial East



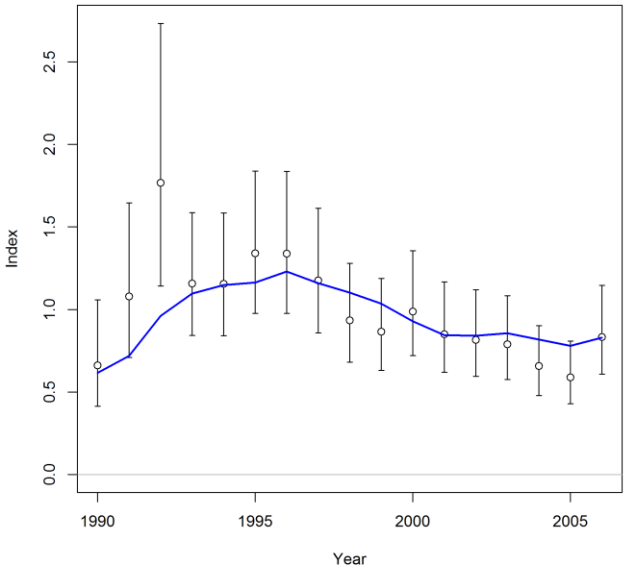

## Recreational (MRIP) East



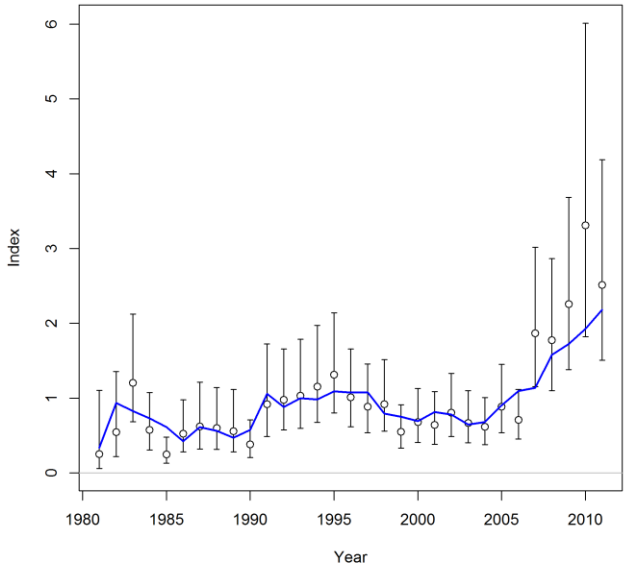

## Headboat East



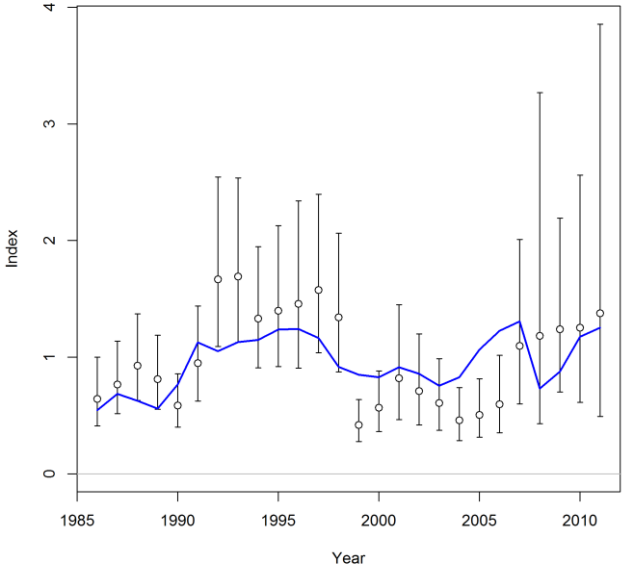

## Commercial West




## Recreational (MRIP) West

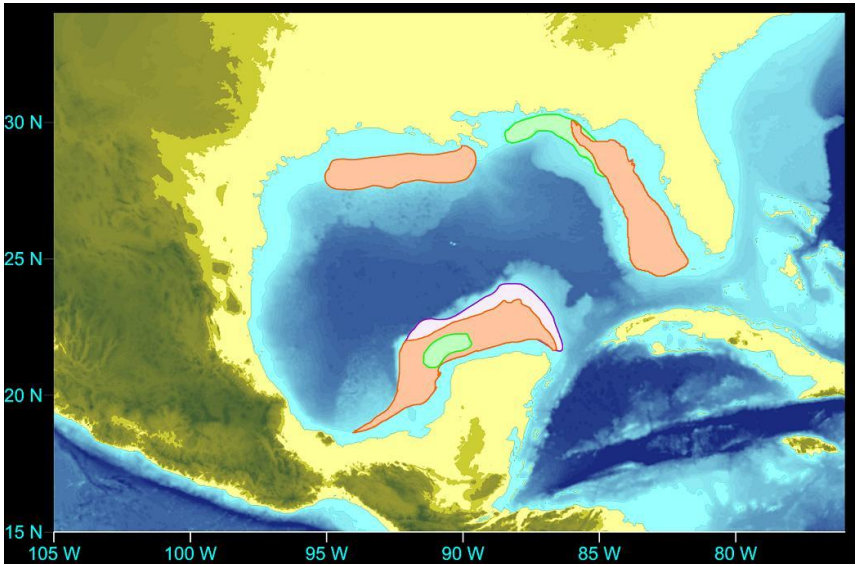


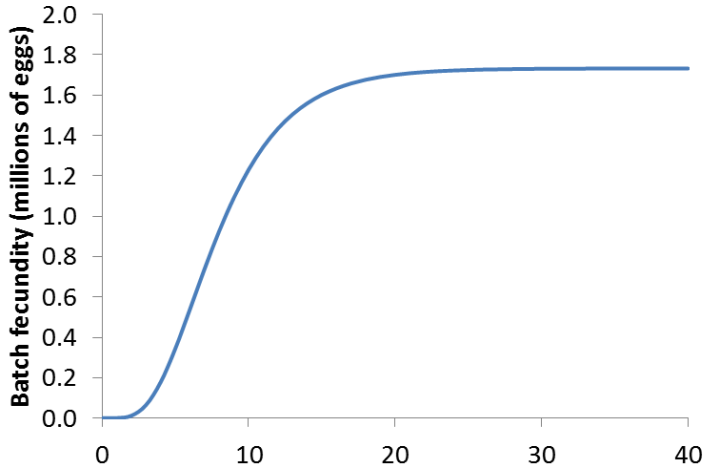

## Headboat West

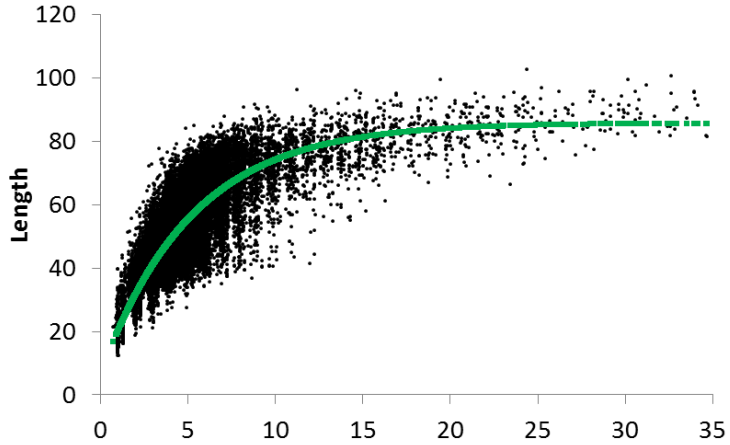


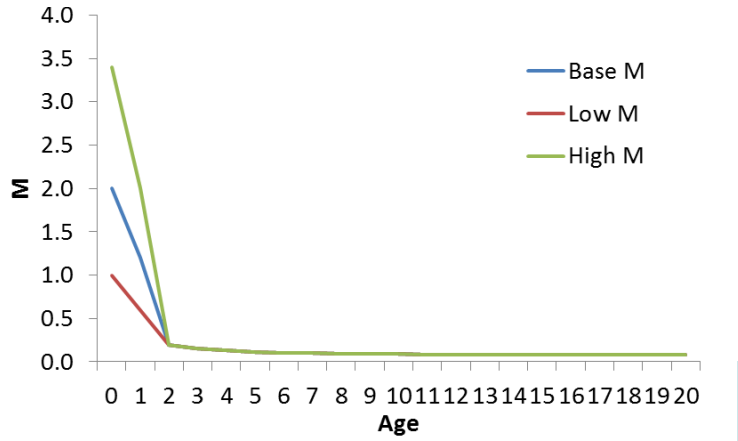
# 5. Biology

- Fecundity
- Mortality
- Growth
- Movement
- Stock structure



# 6. Length / Age Composition

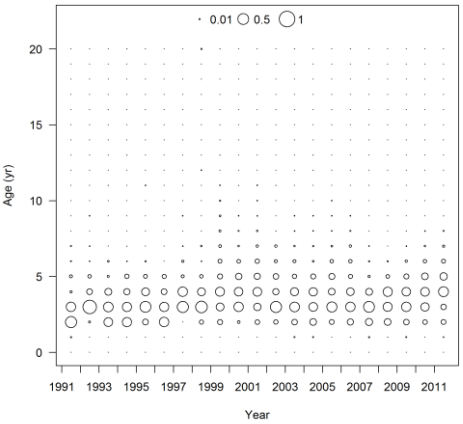
6. Length/age comp

- > 40,000 otoliths
- >200,000 lengths
- Red snapper is a highest priority species for age and growth
- Direct age composition used for all directed fleets
- For some fleets/surveys with only lengths these were converted to age with annual age-length keys
- Used age composition for continuity with previous assessment (we often use age and length in other models)
- Sample sizes input as raw number of fish capped at 200 (different weighting schemes explored as sensitivities)

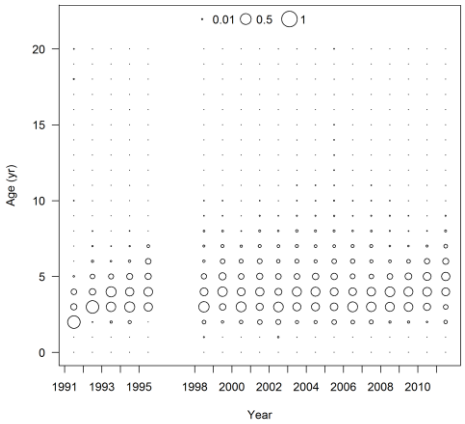
# Age Composition Data – Directed Fleets

6. Length/age comp

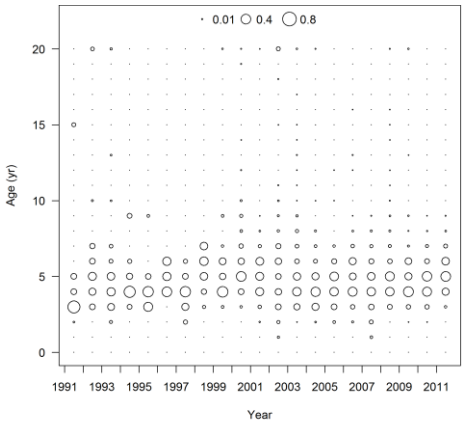
HLE



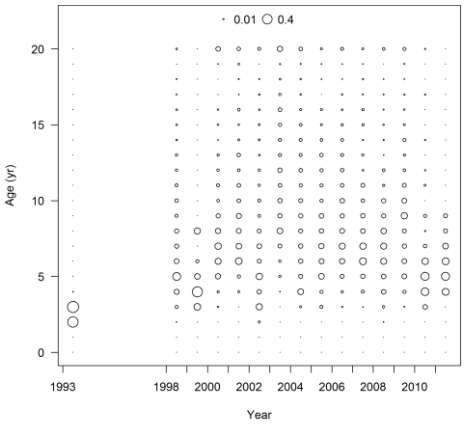

HLW



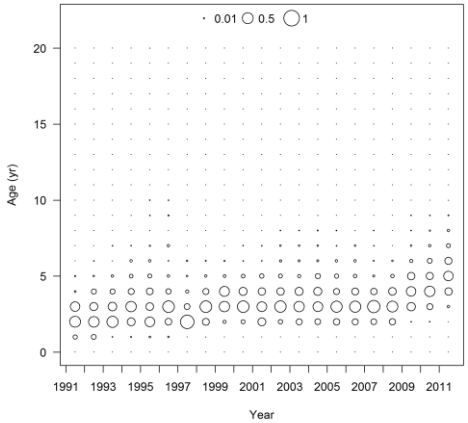

LLE



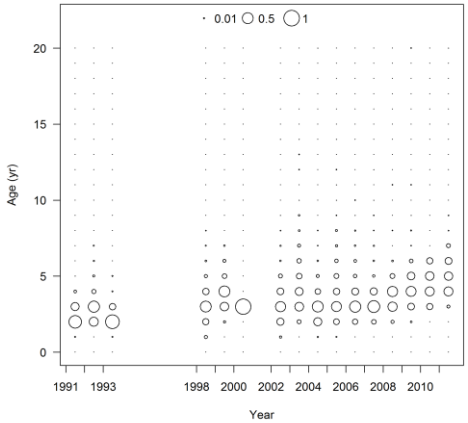

LLW



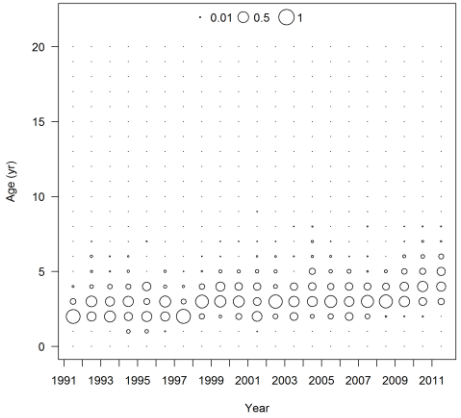

MRIP E




MRIP W




HBT E

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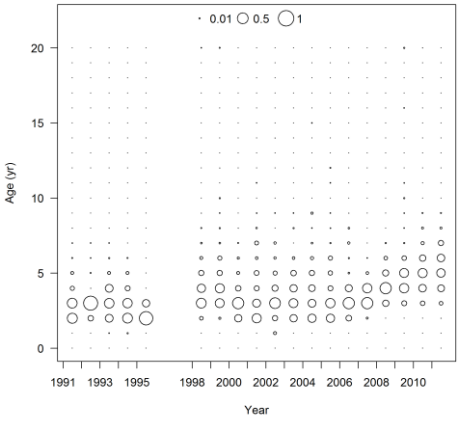
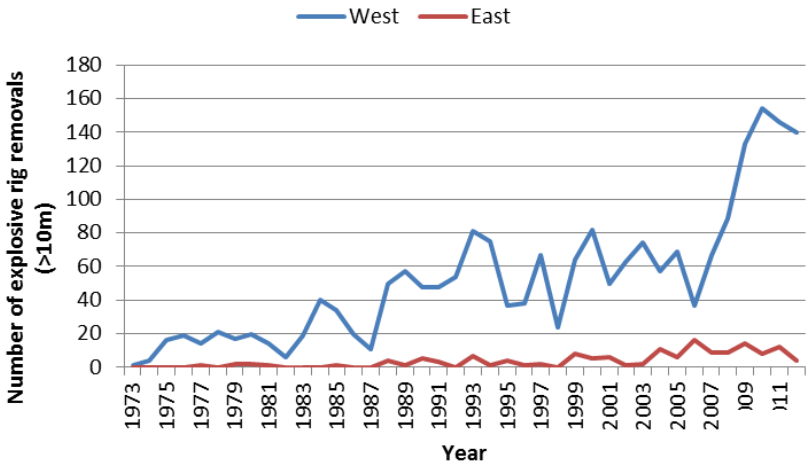


# 7. Environmental / Ecosystem Factors

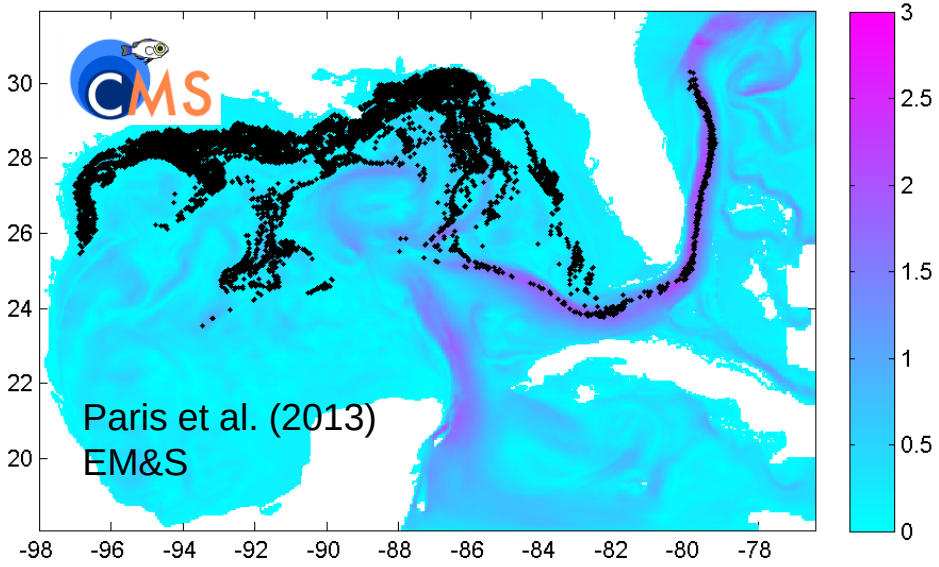


## Explosive Oil Rig Removal Mortality




Attraction versus production

Connectivity modeling



# Basic Model Configuration

- Stock synthesis (SS) integrated statistical catch-at-age model
- Age structured:  ages 0 to 20+
- 2 areas:  east and west of Mississippi River
- 1872 – 2011(assumed virgin in 1872)
- Maturity, fecundity, natural mortality and growth fixed
- Selectivity specified for each age (0 to 20) using random walk where each parameter represents rate of change from selectivity of previous age

# Key Model Specifications

- Single Beverton-Holt stock recruitment relationship with annual distribution of recruits to each area varied
- Model estimated values for steepness ~ 1.0 –steepness set at 0.99
- Two virgin recruitment levels ($R_0$) to account for change in productivity
- Selectivity for NMFS Bottom longline survey modeled as logistic
- Time-varying discard mortality (venting), retention (size limits), and selectivity (IFQ/circle hooks)

## Fishing fleets (14)

### Directed fleets (landings and discards)

- Com Handline E/W (1872-2011)
- Com Longline E/W (1980-2011)
- MRFSS/MRIP E/W (1950-2011)
- Headboat E/W (1950-2011)

### Bycatch fleets (discards only)

- Com Closed Season E/W (1991-2006)
- Rec Closed Season E/W (1997-2011)
- Shrimp Bycatch E/W (1950-2011)

## Indices of abundance (18)

### Fishery dependent (8)

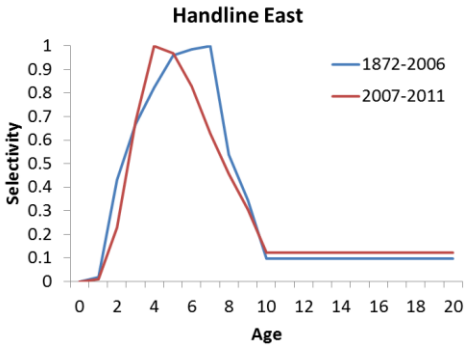
- Commercial Handline E/W (1990-2006)
- MRFSS/MRIP E/W (1981-2011)
- Headboat E/W (1986-2011)
- Shrimp Fishing Effort E/W (1950-2011)

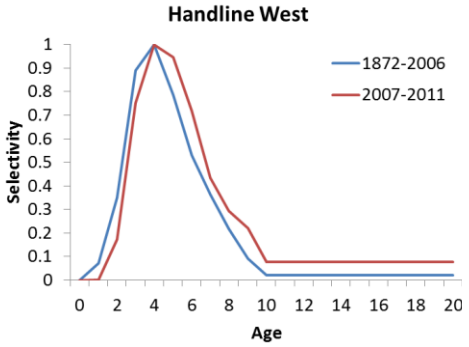
### Fishery independent (10)

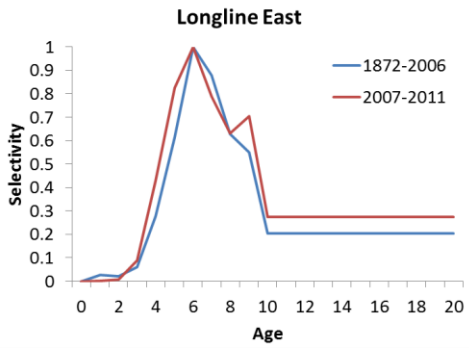
- SEAMAP Video E/W (1993-2011)
- SEAMAP Plankton E/W (1987-2010)
- SEAMAP Summer Groundfish E/W (1982-2011)
- SEAMAP Fall Groundfish Trawl E/W (1972-2011)
- NFMS bottom longline E/W (1986-2011)

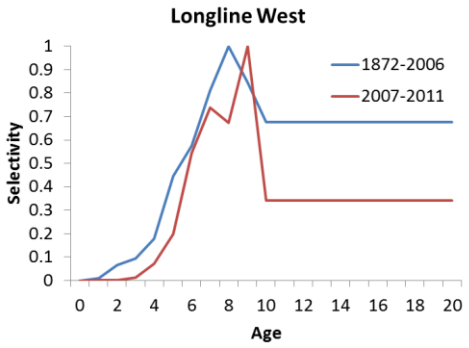
# Model Configuration - Selectivity

## Commercial Fleets

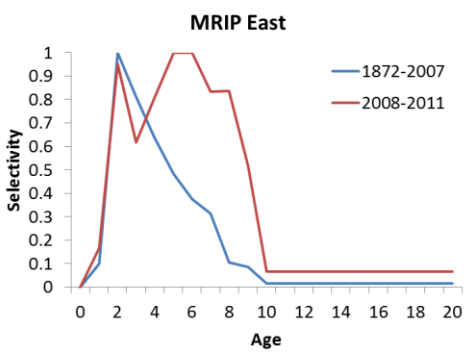


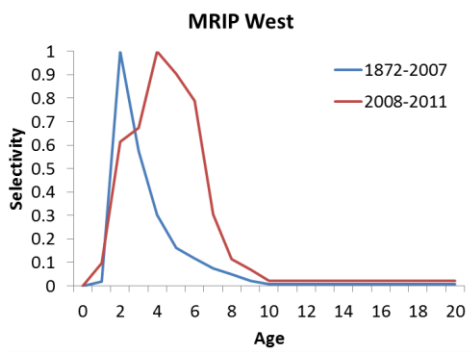



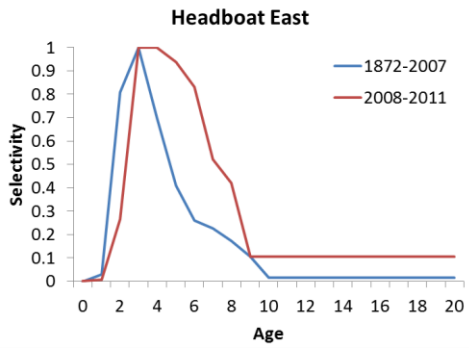



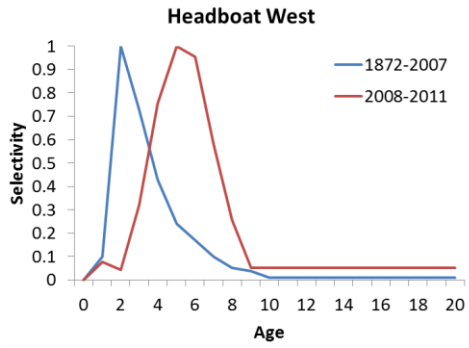




## Recreational Fleets



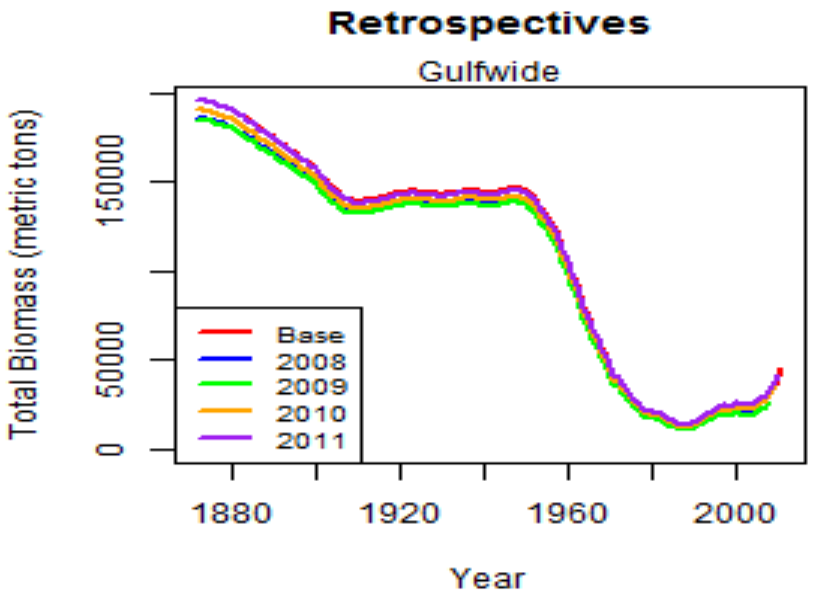



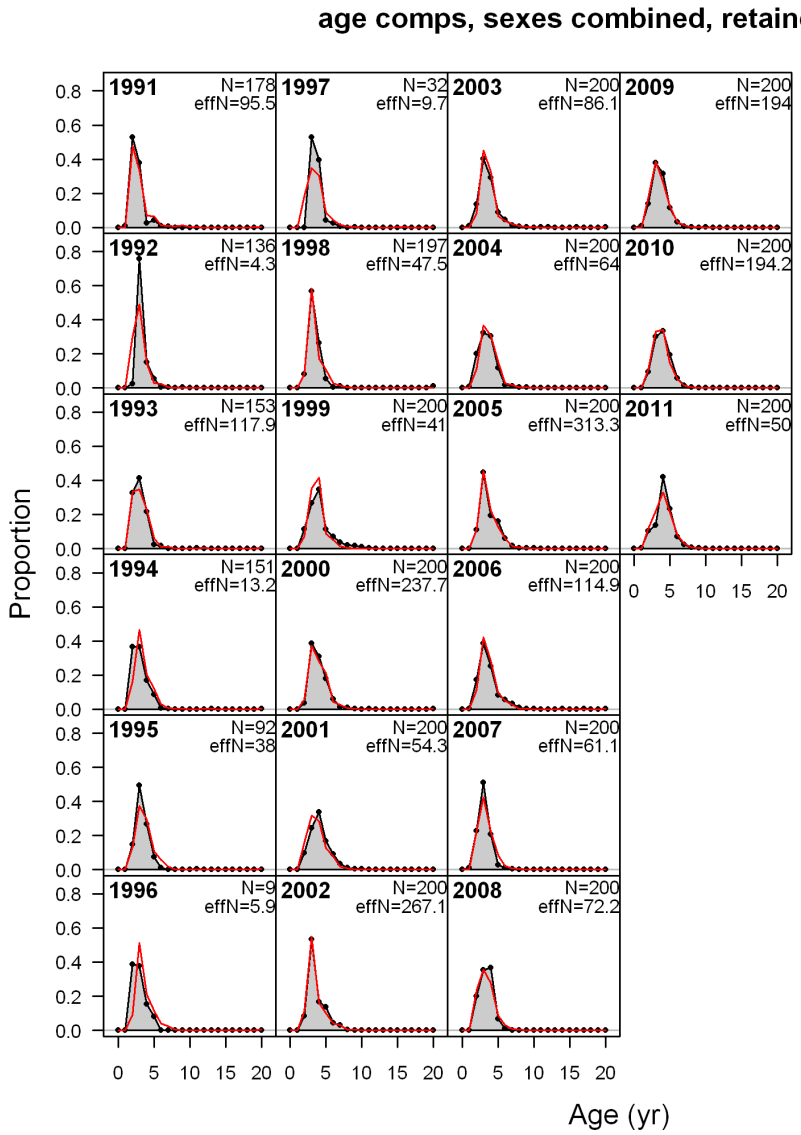

- Commercial selectivity changes with implementation of IFQ in 2007
- Recreational selectivity changes with implementation of circle hooks in 2008

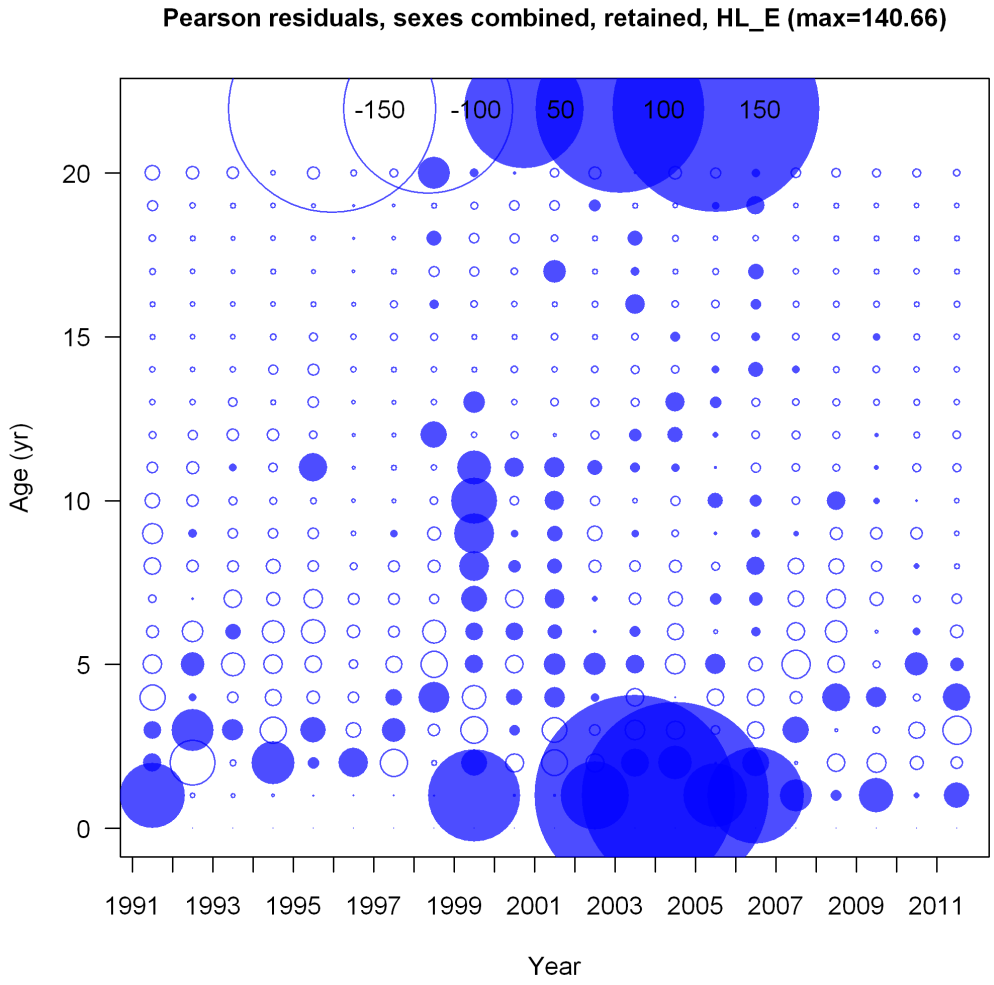
# Model Diagnostics

- Fits to composition data
- Fits to indices/landings/discards
- Likelihood profiling of key parms (steepness, R0)
- Jitter starting values
- Retrospective analyses



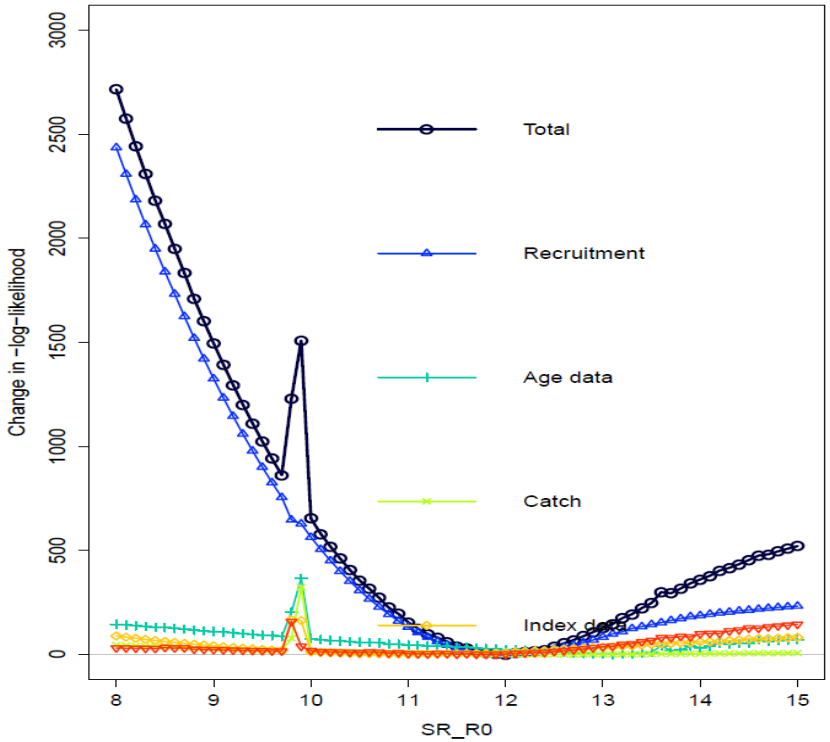
# Fits to Age Comps – Handline East Landings



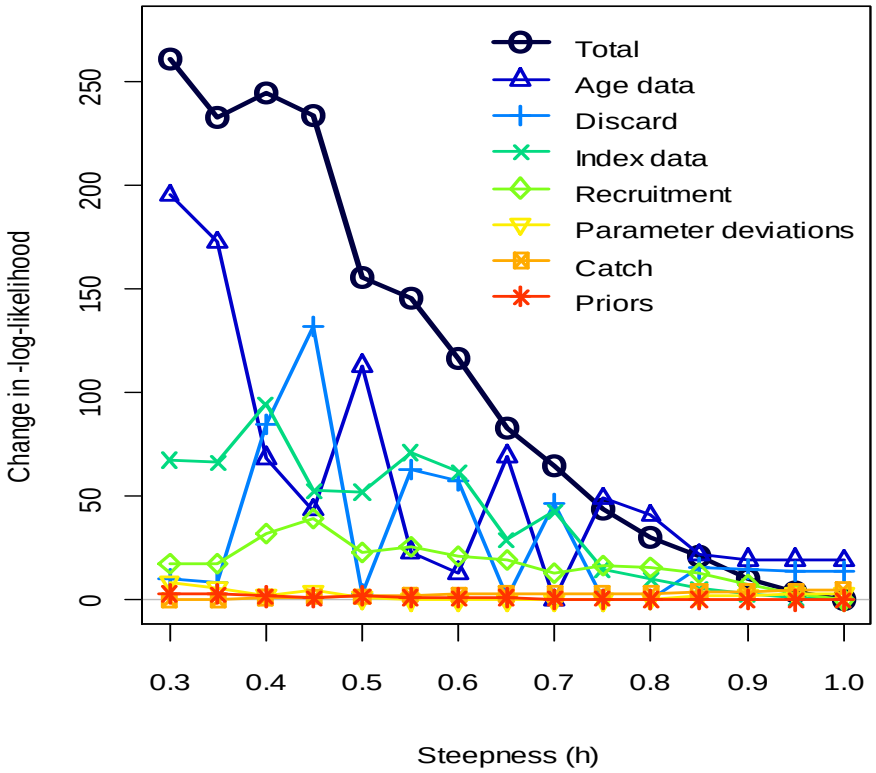



# Likelihood Profiles by Component

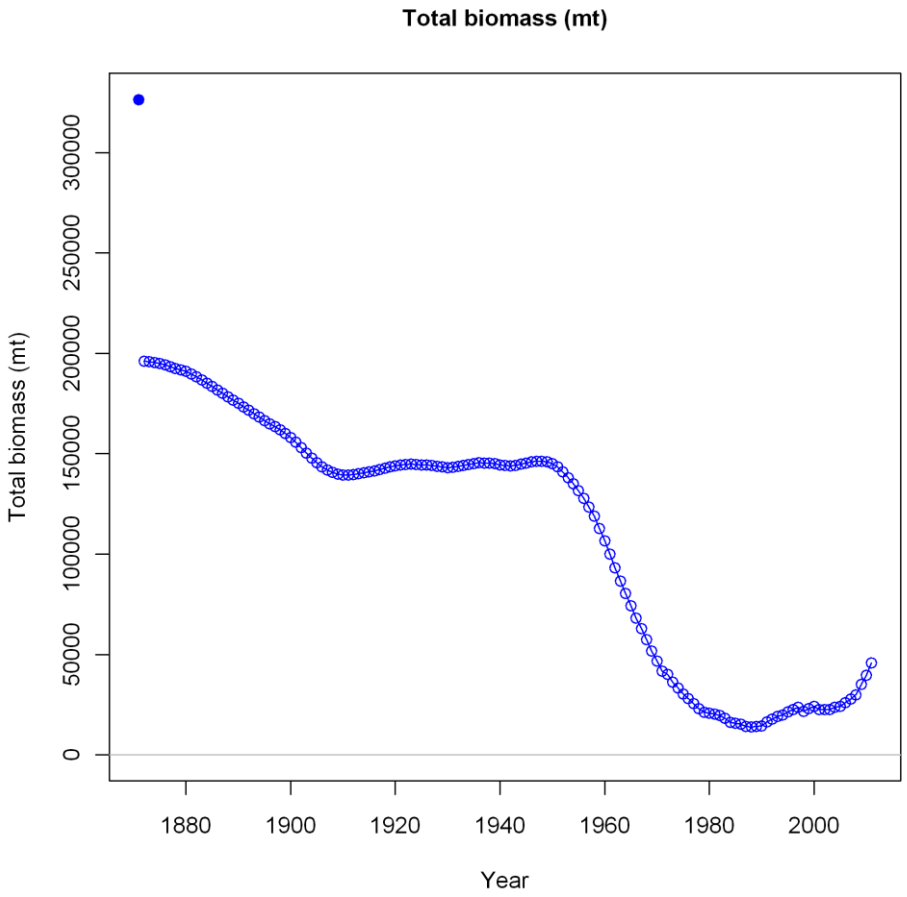
VIRGIN RECRUITMENT

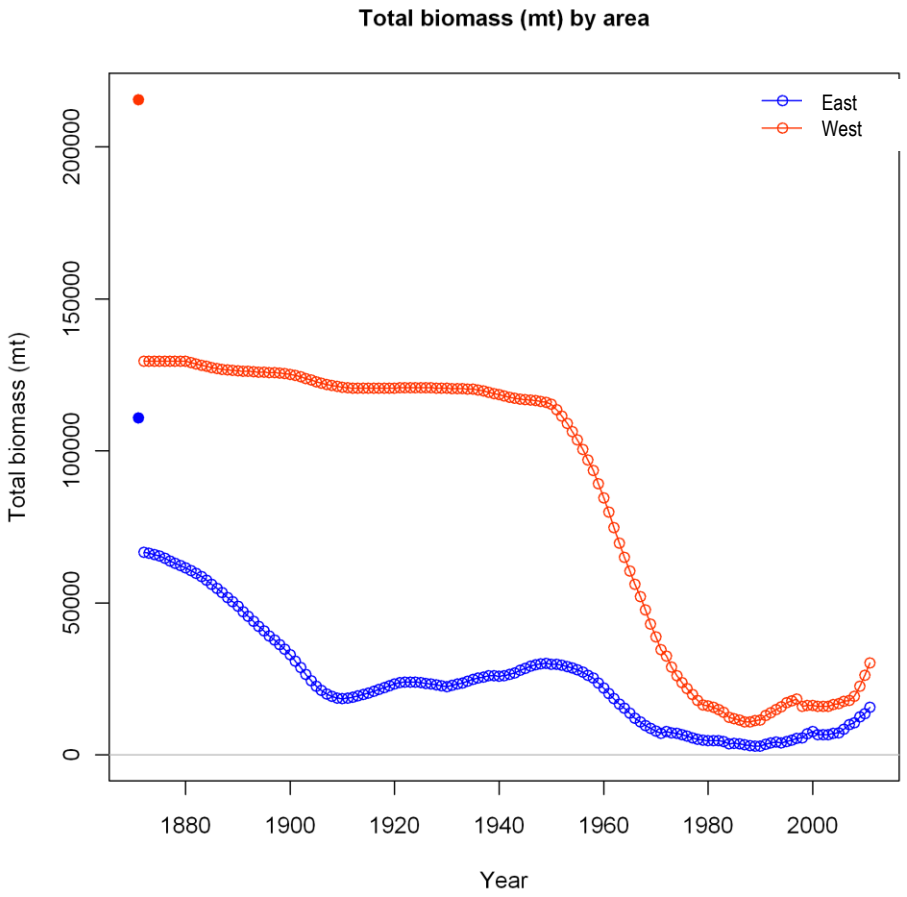



STEEPNESS

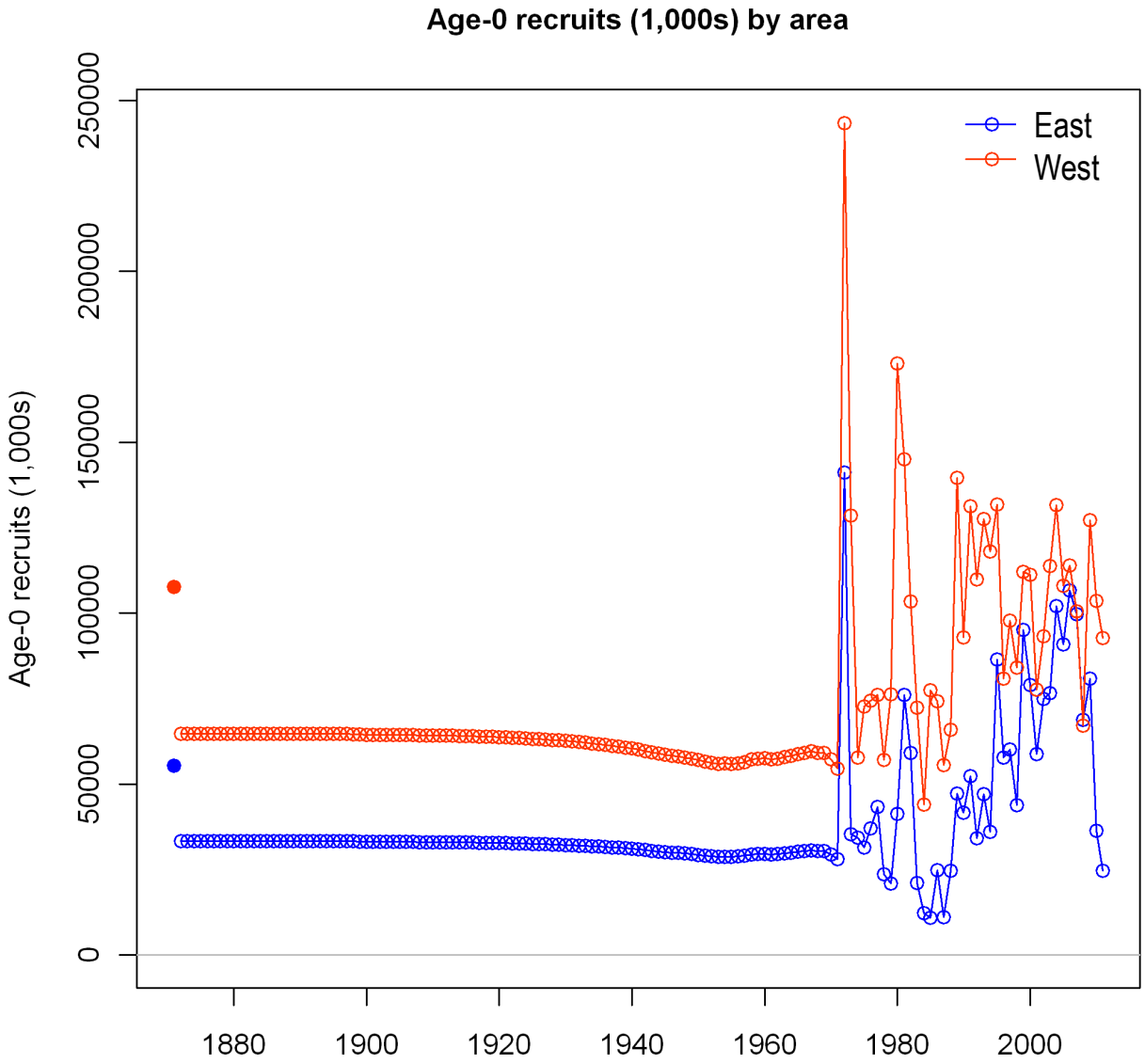


# Model results: Model Estimated Biomass Time Series

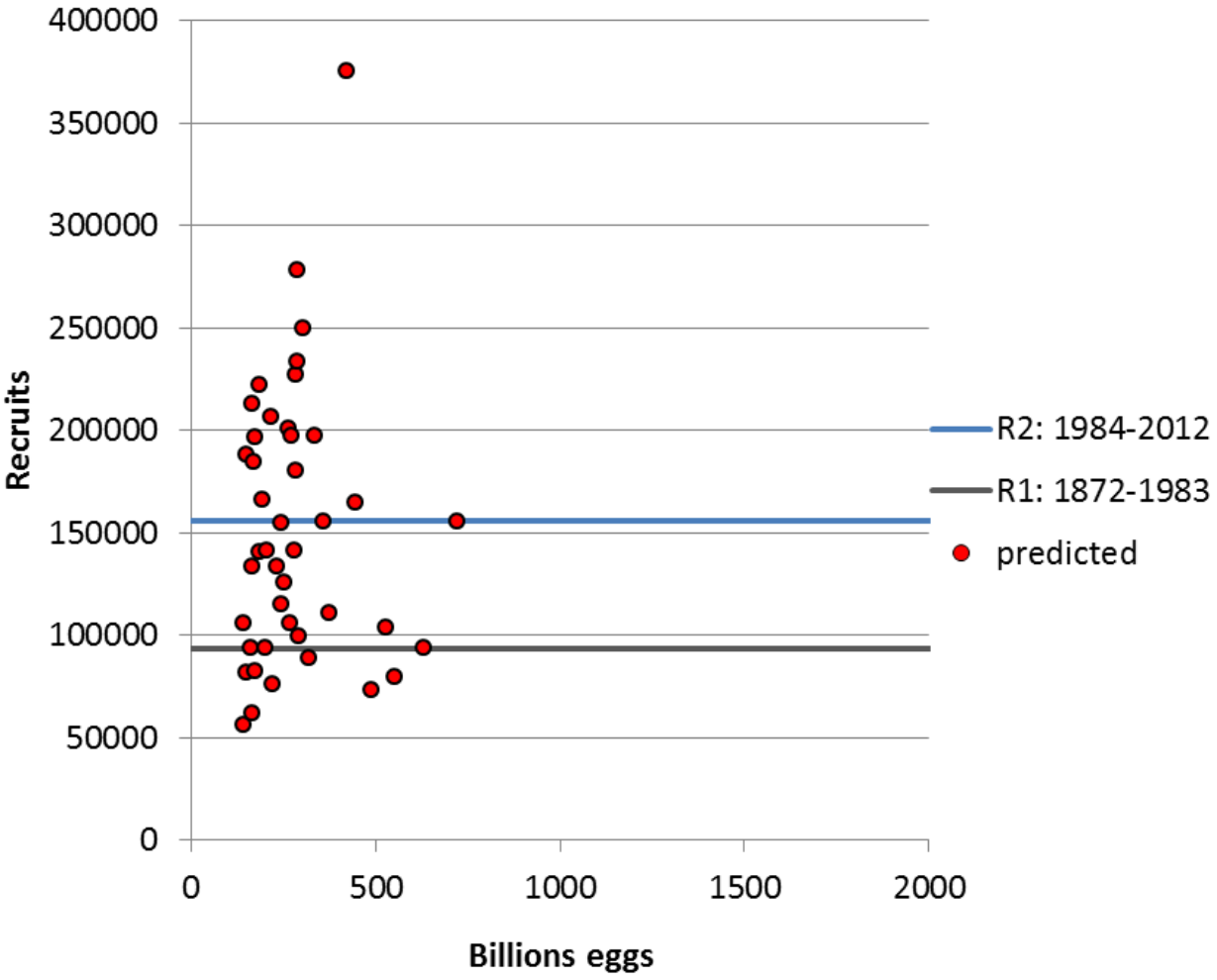


# Estimated Recruitment Time Series



# Stock-Recruitment Relationship




- Beverton-Holt Stock-recruit relationship
- Steepness hits bound at 0.99, fixed at this value

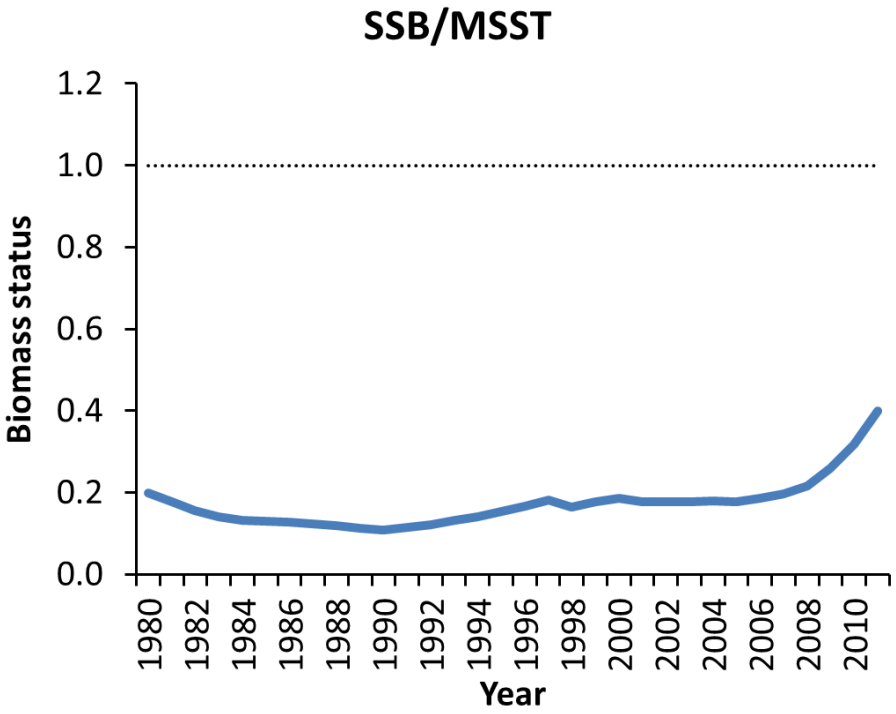
# Status Determination (F and B benchmarks)

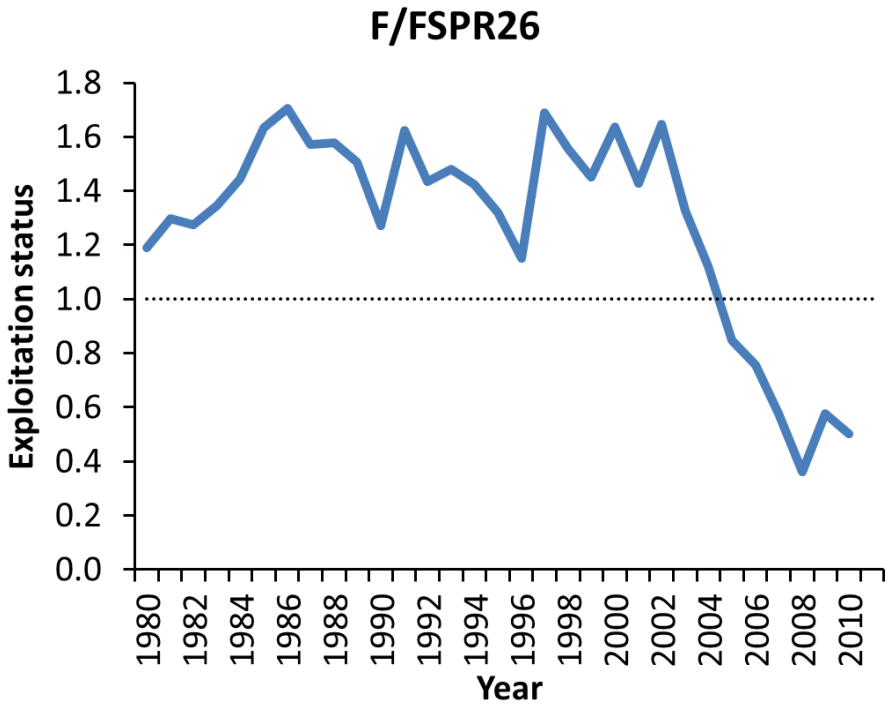
Hierarchy is:

1. Estimated MSY  (Fmsy and Bmsy)
2. SPR (Spawners / virgin spawners per recruit) proxy for MSY (usually 20-40%)
3. Fmax (F at maximum yield per recruit)

As steepness estimates bounded at 0.99, for Red snapper a proxy for MSY was used corresponding to 26% SPR.

# Stock Status Relative to SPR26% Benchmark



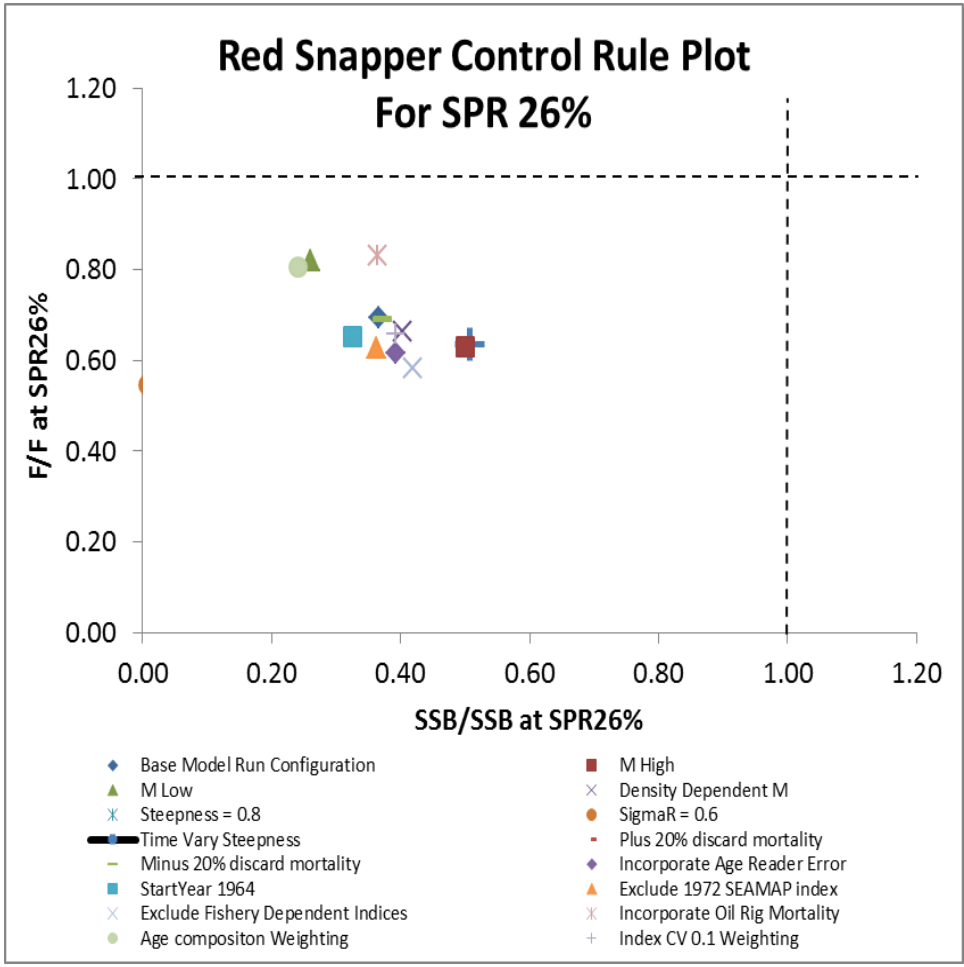




Stock is overfished (SSB < MSST, Minimum stock size threshold) but is not undergoing overfishing

MSST is defined as $SSB_{F26\%}$*(1-natural mortality)

# Model Sensitivities

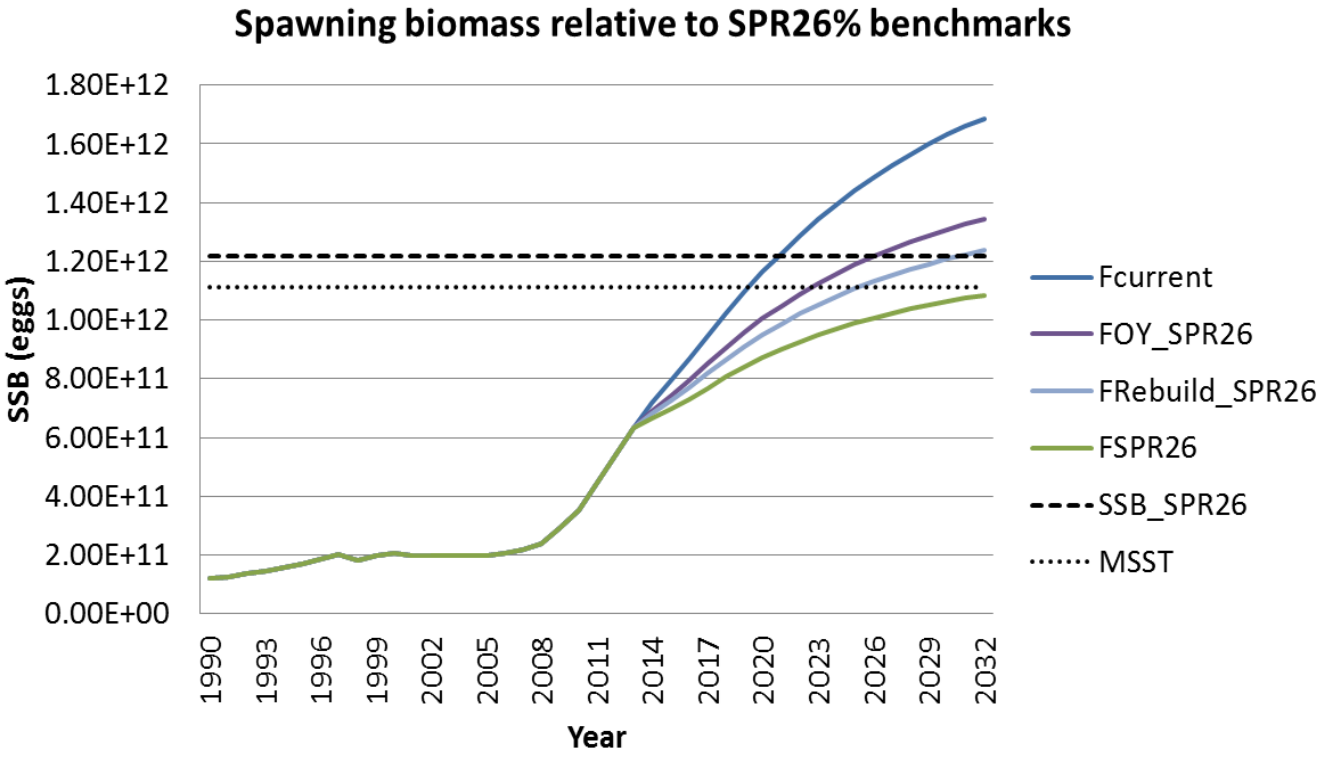
- Data inputs/model configuration
  1. Start model in 1964
  2. Add oil rig removals
  3. Add ageing error
- Data exclusion
  4. Remove 1972 SEAMAP trawl survey observations
  5. Remove fisheries dependent surveys
- Model weighting
  6. Increase weight of indices (CV=0.1)
  7. Increase weight of age composition data (Cap at 100)
- Natural mortality rate
  8. **Increased M on age-0 and age-1***
  9. **Decreased M on age-0 and age-1***
  10. Density-dependent M for age-0
- Discard mortality
  11. Increased/Decreased discard mortality for all fleets
- Spawner-recruitment relationship
  12. Steepness fixed at lower level (0.8)
  13. Time-varying steepness
  14. Increased variation in recruitment deviations




*Runs in red averaged with base model for advice

# Projections – to Determine OFL

- Projections to determine F that would rebuild to SPR26%
- Current 31 year rebuilding plan started in 2001 and ends in 2032




OFL determined as the yield at Frebuild

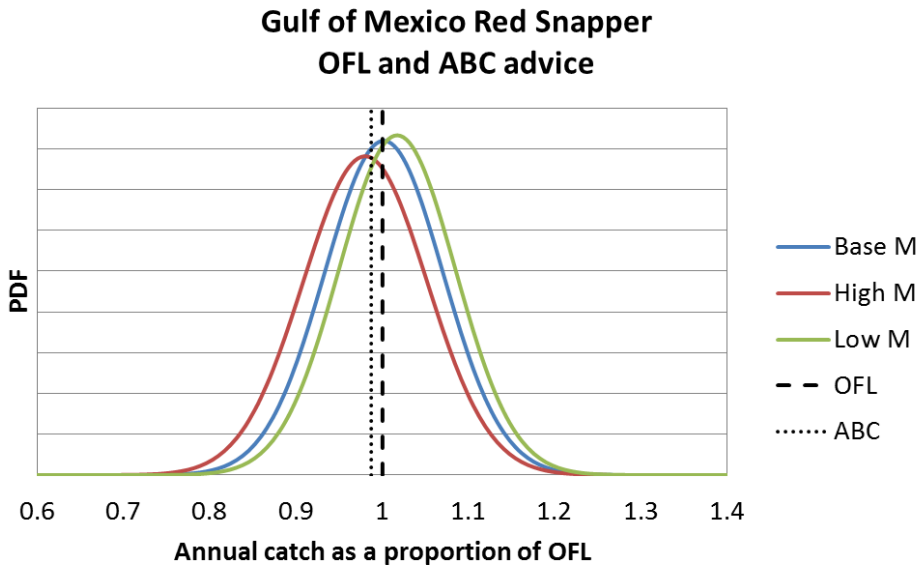
$$\text{Frebuild(SPR26\%)}\ \frac{\text{Rebuilt to SPR26\%}}{2032}$$

# Quantification of Uncertainty for Yield Projection
## (determines buffer between OFL and ABC)

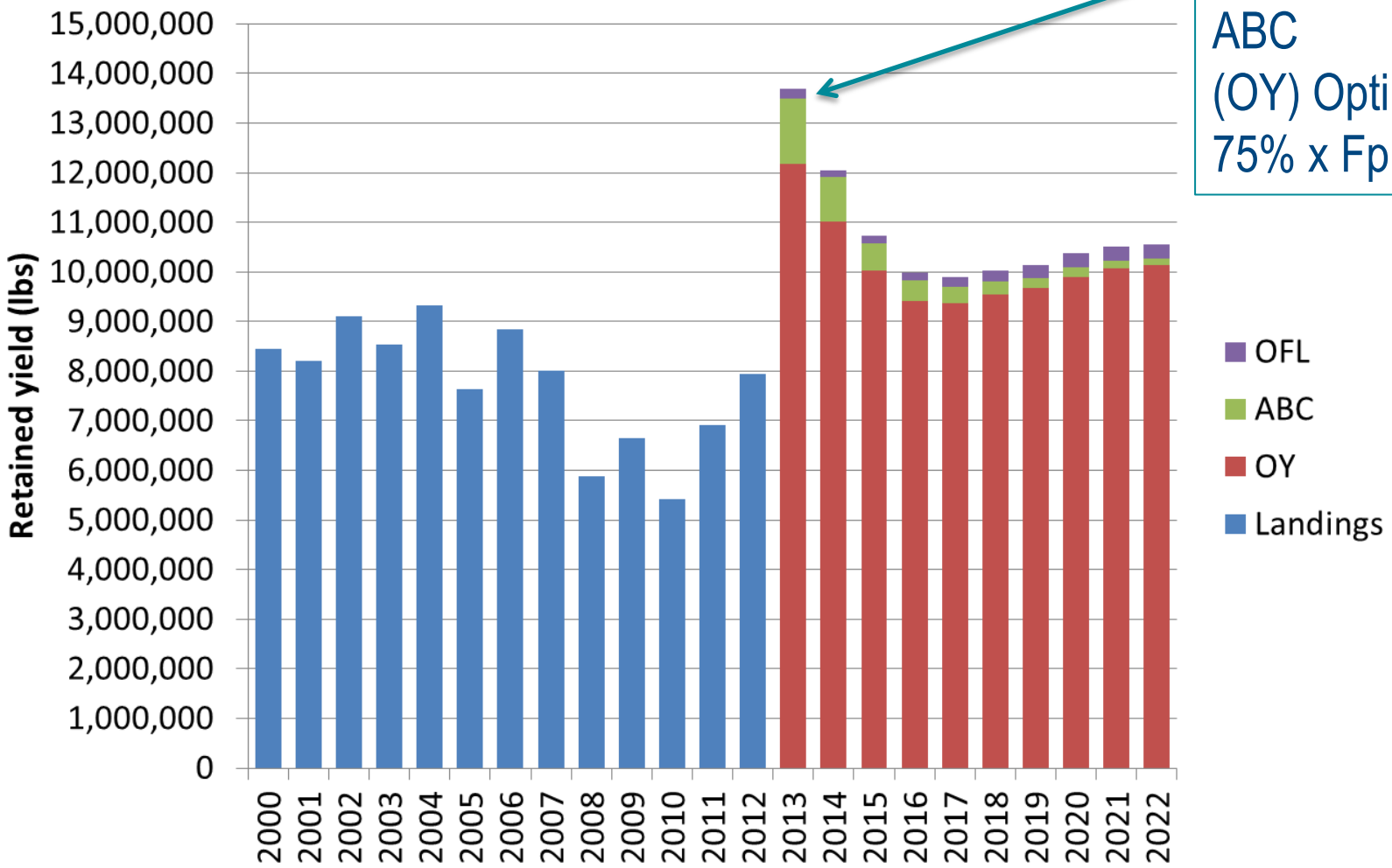
OFL>=ABC>=ACL

- Uncertainty derived using parametric bootstrap approach
- SS uses error assumptions and sample sizes from the input data to generate new data sets
- Model refit to 1000 bootstrapped data-sets and distribution used to represent the uncertainty
- Base, High and Low M runs weighted 50, 25 and 25%

joint distribution of the 3 model runs



# ABC recommendations



# Reports and Documentation

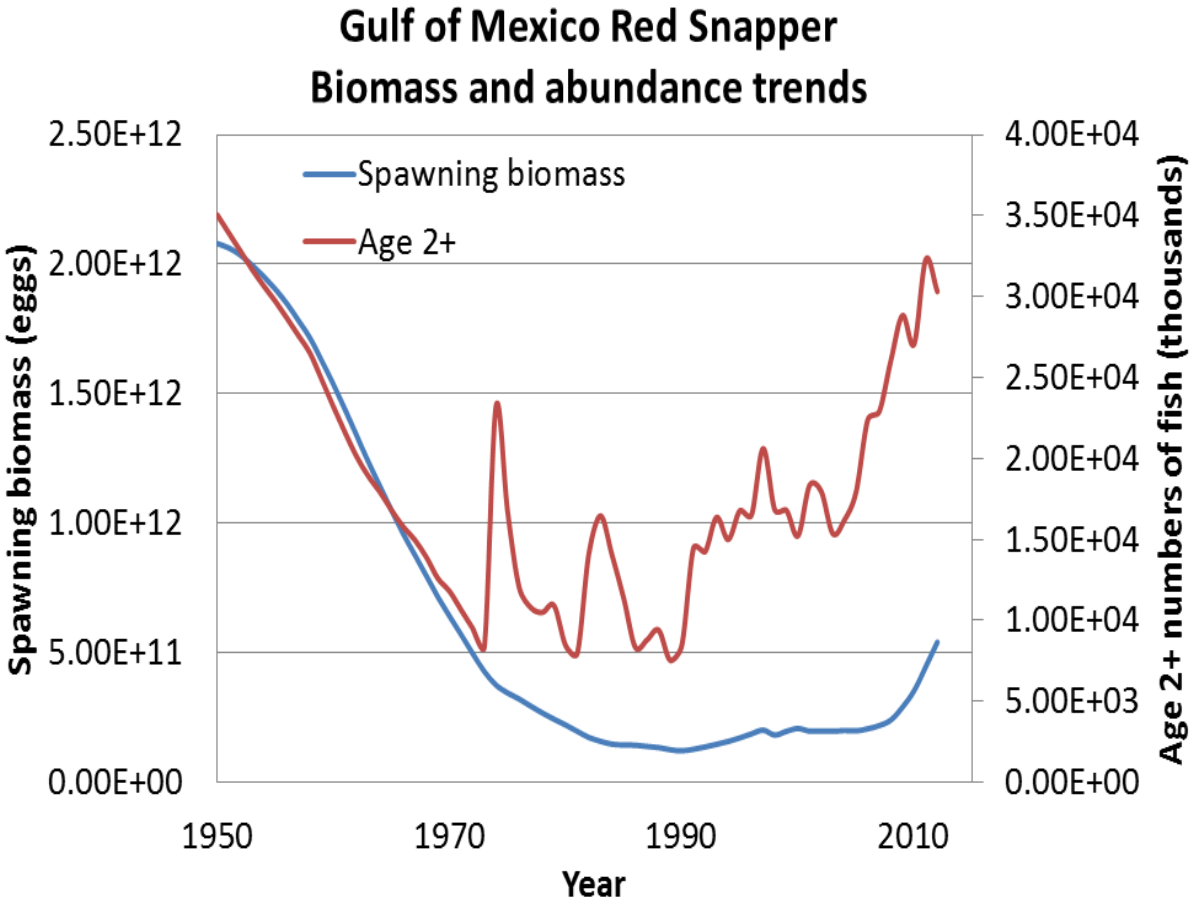
- SEDAR 31
  - 33 Data Workshop papers
  - Data workshop report (367 Pages)
  - 17 Assessment Workshop papers
  - Assessment workshop report (1111 pages)

# Follow-up Analysis

- Presented to SSC and Gulf Council (06/2013)
- Additional analyses
  - Alternative projections (08/2013)
  - Additional projections (01/2014)
  - Slot limit analysis
- IPT (Interdisciplinary planning team)
- Congressional Responses**
- Stakeholder inquiries**

# Why So Much Follow-up analysis: Disconnect between perception and science

- Red snapper are more abundant than in 50 years!
- But must consider history
- Spawning biomass not at level where stock is rebuilt



# Strengths

1. Massive amount of age, length, and biological data
2. Fishery independent surveys, particularly age 0 recruitment index and longline index
3. Long time series back to virgin conditions
4. Priority species for research (MARFIN, Congressional supplement in 2011, Cooperative Research Program)
5. Strong support from academic, state and federal partners

# Challenges

1. Attraction vs. Production (impact of artificial reefs and oil rigs?)
2. Uncertainty in recreational catches
3. Communicating the science to diverse audience
4. Diverse data inputs require substantial time and collaboration
5. Moving target of fishery-dependent CPUEs requires constant gardening
6. Increasing complexity of management advice → greater demands on assessment
7. Changing fishery/system dynamics (e.g. Confounding between changing selectivityand recruitment estimation in last years of models)

# Red Snapper Emblematic of SE Assessments in General

1. Long history of exploitation, prior to solid data
2. Heavy reliance on fishery CPUE
3. Multiple surveys- no single survey to rule them all, often short in duration or spatial coverage
4. Major recreational and release fisheries
5. High level of potential external connectivity, Campeche-Mexico, Gulf-South Atlantic
6. Bycatch from other fisheries a major concern
7. Modeling the past may not always predict the future

# Acknowledgements

SEDAR 31 assessment panelists and assessment team – Notably **Jake Tetzlaff**, **Steve Saul** and **Brian Linton** – Lead Analysts